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BALANCE 4P: Balancing decisions for urban brownfield redevelopment – case studies

Case study report of the BALANCE 4P project of the SNOWMAN Network coordinated call IV

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Cover:
Illustrations for Merwevierhavens, Alvat and Fixfabriken cases studies, based respectively on Mooij (2014), Niel (2014) and Garção (2015).

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ABSTRACT

This report presents three case studies from the Netherlands, Belgium (Flanders) and Sweden, i.e. Merwevierhavens, Alvat and Fixfabriken respectively. The case studies were carried out to explore the possibilities for inclusion of subsurface and sustainability assessments in early planning phases of the brownfield redevelopment process. Stakeholder analysis and the System Exploration Environment and Subsurface (SEES) method were used (i) to identify relevant stakeholders, including subsurface experts, and (ii) to generate redevelopment alternatives with their help in workshop settings and individual consultations. Further, sustainability assessments of the redevelopment alternatives were performed using a number of instruments covering a wide range of sustainability aspects. In particular, Multi-Criteria Analyses, Cost-Benefit Analyses and methods for assessment of ecosystem services were used in the Alvat and the Fixfabriken case studies. In addition, a Social Impact Analysis was performed for the Swedish case. In all three countries, available subsurface information is not systematically treated in the planning process due to established planning culture and insufficient support in policy, law and regulation. The SEES methodology provided important insights to planners on potential benefits of including subsurface knowledge in the early planning phases. Examples of lessons learned from the cases are that direct communication and stakeholder interaction is more efficient than documents, and that it is important to take time and to prepare subsurface information in an approachable form. Further, qualitative and semi-quantitative sustainability assessments seems more useful than quantitative ones, because of data availability constraints in early phases of the redevelopment process and thus high uncertainties in the assessment results, but also due to communication aspects. The lessons learned from the cases is an important input for recommendations on a more structured holistic approach for knowledge exchange between subsurface and surface sectors, and for inclusion of subsurface and sustainability assessments in the planning process.

Key words: brownfield redevelopment, subsurface, planning, stakeholder analysis, contaminated sites, remediation, sustainability assessment, Merwevierhavens, Alvat, Fixfabriken

Contents

Preface

The Balance 4P project was carried out as part of the SNOWMAN Network coordinated call IV (http://www.snowmannetwork.com). The SNOWMAN Network and the national funders in this network are acknowledged for the received support: SNOWMAN (SN04-01), Formas (Dnr 216-2013-1813), Stichting Kennis Bodem (SKB, D3146), and OVAM (VITO contract nr 1310398). In addition, the Municipality of Rotterdam, Port of Rotterdam, Gebiedsteam M4H, Programmabureau Stadshavens Rotterdam and Gemeentewerken Rotterdam are acknowledged for being willing to invest both money and time into the work with the case studies within the research project, and being enthusiastic about it. Hanna Kaplan, Christian Carlsson from the Gothenburg municipality, and Elisabeth Forsberg representing the private developers HSB and Balder are greatly acknowledged for investing time and efforts in the work with the Fixfabriken case study, and always having a positive attitude and being co-explorer, despite limitations in available time. All students and stakeholders participating in the Balance 4P project are acknowledged for contributing with time, their skills, experiences and knowledge.

Project acronym:
BALANCE 4P

Full Project Title:
BALANCE 4P: Balancing decisions for urban brownfield redevelopment – people, planet, profit and processes

Project consortium:
Deltares, The Netherlands
Delft University of Technology, The Netherlands
VITO, Belgium
Chalmers University of Technology, Civil and Environmental Engineering & Architecture, Sweden
Enveco Environmental Economics Consultancy, Sweden
r3 environmental technology, UK

Project coordinator:
Jenny Norrman

Project coordinator organization name:
Chalmers University of Technology

Gothenburg, 2015

Jenny Norrman

List of abbreviation

ATES	Aquifer Thermal Energy Storage
BOM	Brownfield Opportunity Matrix
BR2	Brownfield Remit/Response tool
BTEX	benzene, toluene, ethylbenzene, and xylene
C&P	Cables and Pipes
c-DCE	cis-1,2-dichloroethylene
E.ON	The company e.on, a large energy supplier
ESS	Ecosystem Services
MCA	Multi Criteria Analysis
MNA	Monitored Natural Attenuation
NA	Natural Attenuation
NAP	Normaal Amsterdam Peil (=Mean Sea Level)
NVE	Nature Value Explorer
PCE	Tetrachloroethylene or Perchloroethene or Perchloroethylene or Perc
SA	Stakeholder Analysis
SCORE	Sustainable Choice of REmediation
SEES	System Exploration Environment and Subsurface
SIA	Social Impact Assessment
SME	Small and medium-sized enterprises
TCE	Trichloroethylene
UXO	Unexploded Ordnance

1 Introduction

Land take as a result of urbanization is one of the major soil threats in Europe. One of the key measures to prevent further urban sprawl and additional land take, is redevelopment of urban brownfields: underused urban areas with, in many cases, soil and groundwater pollution, which can be a bottleneck for redevelopment of brownfields instead of green fields. A difficulty for brownfield redevelopments is that in urban projects the responsibilities, tools and knowledge of subsurface engineering and urban planning and design are not integrated; they depend heavily on each other but work in different sectors. The urban designer usually deals with opportunities for socio-economic benefits while the subsoil engineer deals with the technical challenges of the site.

In the remediation sector, there is a broad on-going work to develop methods and tools that supports sustainable remediation. Remediation was earlier viewed as a sustainable action in itself, but today negative impacts of remediation are acknowledged, e.g. transport emissions and fatality risks, health risks during remediation, consumption of energy and materials as well as being costly (Vegter et al., 2003; SuRF-UK, 2010). There is today an increasing demand for assessing remedial activities with regard to all three of the commonly mentioned sustainability dimensions: environment, economy and society. The International Standard Organization (ISO) currently works on a standard for sustainability evaluation of remedial actions and there are several SuRF (Sustainable Remediation Forum) organizations worldwide (USA, UK, Australia & New Zealand, Canada, Italy, the Netherlands, Taiwan and Brazil) that support this development. SuRF-UK suggested a general framework for assessing the sustainability of soil and groundwater remediation, broad enough to apply across different timescales, site sizes, and project types (Bardos et al., 2011). In accordance with Bardos et al. (2011), there are several attempts to incorporate sustainability in early phases of projects, as there is a general idea that the largest (sustainability) gains are achieved early in projects when they are still flexible.

1.1 The Balance 4P project

The background to the Balance 4P project is the idea that a better cooperation between urban developers and sub-surface specialists in early phases of the redevelopment process can accelerate brownfield redevelopment and potentially identify more sustainable redevelopment strategies. The overall aim of the Balance 4P project has been to develop a holistic approach that supports redevelopment of brownfields by integrating technical, economic and social aspects, and provide means for clearly communicating challenges and opportunities of site-specific subsurface qualities. The main findings of the Balance 4P project are reported in Norrman et al. (2015).

1.2 Aim and scope of the case study report

One important method in the Balance 4P project has been to use real case studies as a mean of applying and testing the outcomes of different activities and instruments. This report is part of the final reporting to the SNOWMAN network presenting the work in the three case studies carried out within the Balance 4P project in the Netherlands, Belgium (Flanders) and Sweden. A description of the study sites, results of stakeholder

analysis, the process of generation of redevelopment alternatives and their assessments, as well as advices are provided for each case in sections 2 - 4. Within these sections, there are text boxes that shortly introduces the different instruments applied in the cases. Results from an international on-line webinar that was held to receive feedback on the case study work from case holders and other practitioners is presented in Section 5. Section 6 concludes the report with the main findings from the case study work.

1.3 Overview of the case studies

The three studied sites have different characteristics regarding the subsurface conditions, ownership relations, development visions, governance, and the phase of the redevelopment process (Table 1-1).

Table 1-1. Brief overview of the case study sites.

CASE STUDY / LOCATION	PROPERTY TYPE	PHASE	COMMENT
Merwevierhavens/ Rotterdam, The Netherlands	The east part "city harbours" that is going to be redeveloped from mainly being an industrial area into an area with mixed use.	Initiative	A lot of data on subsurface was available, but was rather focused on subsurface problems than chances.
Alvat/ Buggenhout, Belgium	An abandoned and underused industrial area located along the river Scheldt. There is no clear vision on future land use.	Plan	Extensive investigations and partial remediation of the contaminated soil were carried out.
Fixfabriken/ Gotenborg, Sweden	A former industrial area located in an attractive part of the city is going to be redeveloped into an area with mixed use.	Plan	Limited information on contamination and other subsurface conditions e.g. archaeology, geotechnical situation.

The Merwevierhavens (The Netherlands) and the Fixfabriken area (Sweden) are former industrial areas which are going to be transformed into areas with mixed uses. In the Fixfabriken site, there is going to be residential housing. For the Merwevierhavens site, this is still a long term plan, instead mixed use is first going to be established with other businesses or cultural functions. The Merwevierhavens site is the initiative phase of the redevelopment process, whereas Fixfabriken is in the plan phase. Both sites are attractive for developers because of good communication possibilities and the central location in the city, which significantly influences property values and thus allows for a market-based redevelopment. The Alvat case (Belgium) is also a former industrial area but differs from other two sites, because public interventions are needed for remediation of the heavily contaminated soil and the site redevelopment. The Alvat site is in the plan phase, however no clear vision on future land use was yet developed, because of the presence of a serious soil contamination and an uncertainty about the ownership situation (the site owner has got bankrupt).

For each case study, different instruments were used during the stakeholder analysis, the generation of redevelopment alternatives and their assessment (Table 1-2). The instruments are shortly introduced in text boxes within the cases where they appear first.

Table 1-2. Brief overview of the applied instruments to each case study.

CASE STUDY / LOCATION	APPLIED INSTRUMENTS		
	Stakeholder analysis	**Generation of alternatives**	**Assessment of alternatives**
Merwevierhavens/ Rotterdam, The Netherlands	• Crosby method	• System Exploration Environment and Subsurface (SEES) in workshop setting • Brownfield remit/response tool (BR2) • Brownfield Opportunity Matrix (BOM)	(not focused on assessing alternatives)
Alvat/ Buggenhout, Belgium	• Crosby method	• SEES (individual stakeholder consultation)	• Risk assessment • Economic assessment (potential profit private redeveloper) • OVAM Multi-Criteria Analysis (MCA) incl. CO_2 calculator • Nature Value Explorer (NVE) –Ecosystem services valuation • Biodiversity check
Fixfabriken/ Gothenborg, Sweden	• Crosby method	• SEES (workshop setting)	• SCORE (Sustainable Choice of REmediation), incl. Cost-Benefit Analysis (CBA) • ESS mapping (Ecosystem Services' mapping) • Social Impact Analysis (SIA)

2 Merwevierhavens in Rotterdam, the Netherlands

The current harbour activities are moving to the west part of the harbour of Rotterdam and therefore the east part, "city harbours", will be redeveloped from mainly being an industrial area into an area with mixed use. This may be residential housing on the long term; mixed use is first going to be with other business or cultural functions. The driver for the redevelopment is urban renewal. The land is owned by municipality and several private companies. The phase of the redevelopment is mainly in the initiative phase: vision-building.

There is a high potential for the subsurface at this site: a lot of data is available, but previously the focus was mainly on problems, whereas chances were not yet being explored. The main questions for the program bureau for the redevelopment were: What are the innovative possibilities for the subsurface in relation with the aboveground redevelopment? How can we use subsurface in the development strategy?

Within the Balance 4P project, a number of activities were carried out in order to find answers to the above questions. All activities described in this report were carried out during the period December 2013 – December 2015. The activities to identify sustainable redevelopment strategies considering the subsurface conditions were:

- Stakeholder analysis (quick-scan & for workshops);
- Stakeholder workshop 1: SEES – System Exploration Environment & Subsurface
  - Chances and challenges for the whole area;
- Stakeholder workshop 2: zoom in E.ON, gasworks, Ferro/Eneco strategies for:
  - Contamination;
  - civil structures;
  - energy;
- An investigation to entering subsurface in "products" (development strategy, tender documents (Stadshavens Rotterdam, 2013-I, 2013-II, 2014)) for Merwevierhavens;
- Preparation of operational advice for the *Stadshavens* Vision and the location E.ON/Ferro/Eneco including a subsurface potential map;
- Student workshops and projects:
  - SEES workshop;
  - Aqua-Terra Urban Design projects;
  - Tool inventory and application (Brownfield Remit/Response (BR2) tool and Brownfield Opportunity Matrix (BOM)).

2.1 Site description

The *Stadshavens* (City harbours) of Rotterdam are located in between the Benelux tunnel and the Erasmus Bridge. It is a collection of harbour areas covering 1.600 hectares. After the completion of the western extension of the harbour (Maasvlakte 2) in 2013, the port activities shift further and further towards the North Sea. The old harbours near the city centre of Rotterdam become available for urban renewal. Figure 2-1 illustrates the city harbours of Rotterdam.

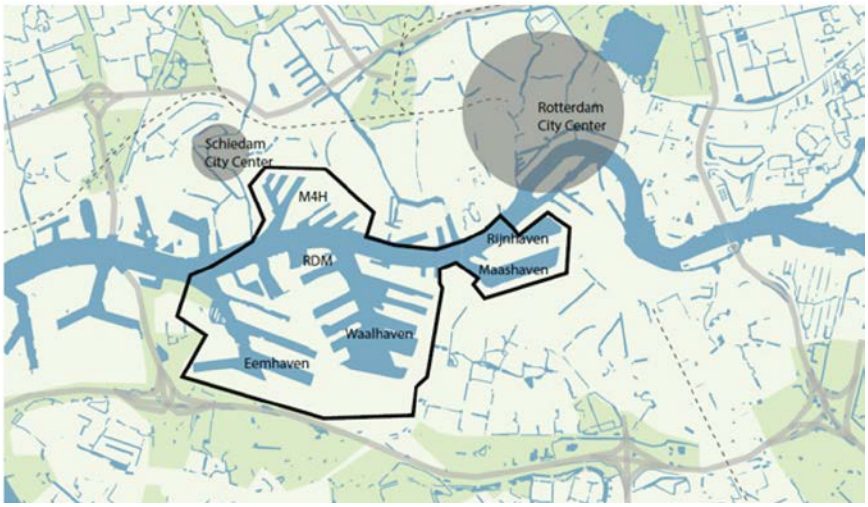


Figure 2-1. City harbours of Rotterdam (Ramkisor, 2014)

The city harbours of Rotterdam are redeveloped in a large project, on both sides of the river Meuse. The whole area is in transition and will become available for urban functions, while the harbour functions are moving or changing. The objective is to mix urban and harbour activities. At first the idea was to realise a more intensive residential area, but because of the financial crisis and the well-functioning clean tech medical and food activities, the latter is being promoted in the area.

In the Balance 4P project, focus was put on one part of the harbour area, Merwevierhavens (see Figure 2-2). For this area during a development strategy has been made (draft version October, Stadshavens Rotterdam, 2014). The redevelopment is being performed by the municipality and the port of Rotterdam together. There are three tracks from "aboveground":

- Mapping "what is there";
- Development strategy, vision for 2035 (5 to 7 years, 'no-regret' program that will contribute to the final goal for the area whatever the scenario);
- Acquisition and area branding (was fruit harbour). The harbour has no future for the current activities. The program bureau for the redevelopment is redeveloping the area in an 'organic' way, anticipating on current markets that still do well in the area and aim for getting new companies in the area, pioneers in the clean tech, medical & food, creative industry.

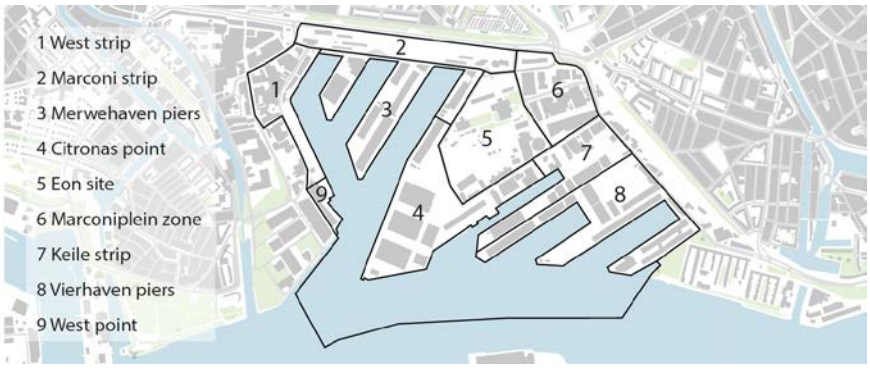


Figure 2-2. The Merwevierhavens (M4H) and sub regions (Ramkisor, 2014)

One of the main objectives of the redevelopment is to use the waterfront for high quality urban development. The area is well connected to the regional and national road system and the Marconiplein zone (zone 6 in Figure 2-2) is well connected to the rest of the city via public transport. The accessibility by both car and public transportation and the proximity to both the centre of Schiedam and Rotterdam make M4H an attractive location. This can further improve if the water net is extended. The main problem is reaching the inner parts of the area from the well accessible edges. There is no designated space for slow traffic and the streets that border the area also form borders for pedestrians and cyclists from surrounding areas. Street patters and lay-out as well as transportation links need to be improved.

The Rotterdam municipality wants to transform the area into a lively living and working environment. There are some typical characteristic elements in the area which, if preserved, could support the identity of the place: old abandoned train tracks, cranes and warehouses that can be re-used. There are already a lot of facilities located in the immediate vicinity of M4H, thus the development of dwellings would not require extra facilities.

During the Balance 4P project, some initiatives in the redevelopment were taking place: The Ferro terrain (3.5 ha, at site 5 in Figure 2-2) was acquired in 2013 by a real estate organisation. Further, a concert hall was planned to be realised in the former gasholder of the Ferro location (planned December 2014) (see Figure 2-3).

Figure 2-3. Ferro gasholder http://3voor12.vpro.nl/nieuws/2014/oktober/Rotterdam-krijgt-concertzaal-voor-6000-man---Ferro-Dome-wordt-vergelijkbaar-met-HMH-.html

2.2 Stakeholder analysis

For the quick scan of the stakeholder analysis for Merwevierhavens Rotterdam, most data on stakeholders was derived from an extensive analysis of the redevelopment area, in the "Rotterdam Stadshavens business case" (2009)[1]. For the purpose of the Balance 4P project, a subset of stakeholders was selected who were invited to the workshops in the Balance 4P project. For this stakeholder inventory, the general steps of the procedure for stakeholder analysis was followed (see Table 2-1).

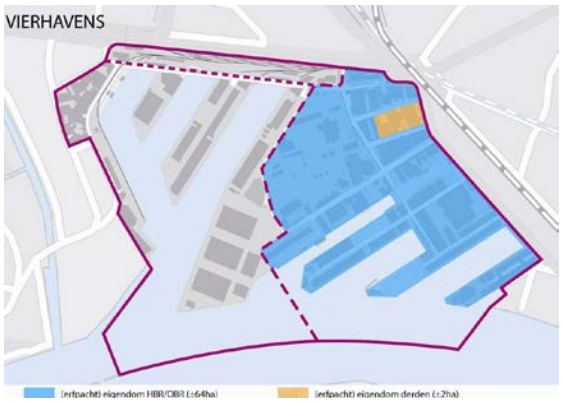
Table 2-1. General steps of the procedure for stakeholder analysis (SA) of the Crosby method (Hermans, 2005)

STEP	CROSBY METHOD
General purpose of SA	Involve people for the Balance 4P workshops for Mewevierhavens
Identify stakeholders	Draw initial ample list of stakeholders and their relative importance. Done with input of the Rotterdam Stadshavens business case (2009).
Collect primary input data	Use local informants to complete stakeholder table based on short stakeholder inventory for the Balance 4P workshops with project bureau M4H
Structure and analyse data	Fill in stakeholder tables / matrices (Table 2-2)

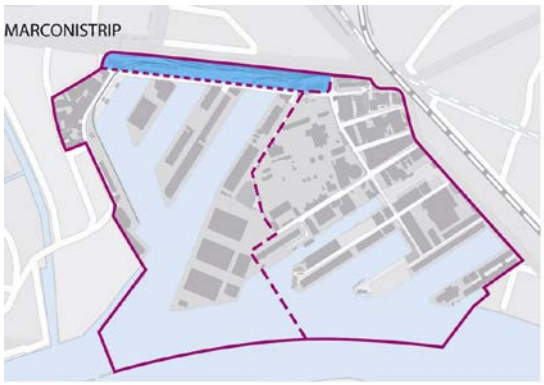
[1] ROTTERDAM STADSHAVENS BUSINESS CASE Definitief 14 juli 2009. Chapter 5 projecten in de Merwe- en Vierhavens.

2.2.1 Broad stakeholder analysis for whole area

First we give the results of Rotterdam Stadshavens business case (2009). The area was divided in three subareas in this study: Vierhavens, Marconistrip and Merwehaven, see Figure 2-4. For each of the areas, an analysis of the stakeholders and their involvement was made.



a) Vierhavens



b) Marconistrip

c) Merwehaven

Figure 2-4. Subareas of the broad analysis for Rotterdam Stadshavens business case (2009)

Table 2-2 presents the results of the stakeholder analysis. In bold, it is indicated where adaptations were made to the current situation (e.g.: the Dutch Ministry of Infrastructure, Spatial Planning and Environment is now the Ministry of Infrastructure and the Environment).

Table 2-2. Analysis of the stakeholders and their involvement Rotterdam Stadshavens business case (2009)

GROUP	INVOLVEMENT GROUP'S INTEREST IN ISSUE	RESOURCE	INVOLVED IN:		
			Vierhavens	Marconistrip	Merwehaven
Ministry of Infrastructure and Environment	Active involvement Declaration of intent RCC (Rotterdam Climate Campus) **(not realised. Not actual anymore?)** tuning in and sets frameworks (manages national highways)	Decision maker Regulator	x		
Ministry of Economic affairs	Support in finding possibilities for subsidies	Decision maker Regulator	x		
Province of South Holland	Regulatory frameworks for some sub areas Support in finding possibilities for subsidies	Decision maker Regulator	x	x	x
Port of Rotterdam **Now in program bureau M4H**	Active involved in working groups Partnership agreement	Decision maker	x	x Largest land owner	x Largest land owner
Initiators RCC(not realised. Not actual anymore?)	Declaration of intent RCC (Rotterdam Climate Campus). **(not realised. Not actual anymore?)** Active role in physical transition of the area	Decision maker	x		
Hoogheemraadschap Delfland (waterboard)	Involve in planning and regulatory frameworks for the area, especially on the subject of quays and dikes	Decision maker	x	x	x
Owners current real estate / properties	Involve in marketing research Actively involved in (re)development	Party with an interest	x	X involve or not. In case of buying up the land	
Current companies / entrepeneurs	Involve in urban debate on future Vierhavens Actively involved in (re)development Inform on progress of project **Enter in transition arena (new interactive manner of area development)**	Party with an interest	x	X Inform to avoid objections and opposition	X discuss premature end of ground lease contracts. Work together on moving current activities (especially fruit cluster)
Companies / entrepeneurs Waal/ Eemhaven	Draw up a administrative agreement influence area Waal-/Eemhaven	Party with an interest	x	x	
Neighbouring municipality Schiedam	Monthly consultation meeting **Enter in transition arena (new interactive manner of area development)**	Party involved	x	x	x

Table 2-2. Continued

GROUP	INVOLVEMENT GROUP'S INTEREST IN ISSUE	RESOURCE	INVOLVED IN:		
			Vierhavens	Marconistrip	Merwehaven
Borough Delfshaven	Involve in monthly meeting Delfshaven Involve in 4-yearly strategic management meeting Delfshaven Involve via Platform Economy Delfshaven **Enter in transition arena (new interactive manner of area development)**	Party involved	x	x	x
Housing corporations	Involve via market consultation and marketing research Possible involvement in development sub-areas or sub-projects after selection	Party involved	x	x	
City region	Involve in urban debate on future Stadshavens + public transport over water Support in finding possibilities for subsidies	Party involved	x	x	x
Project developers and investors	Involve via market consultation and marketing research Possible involvement in development sub-areas or sub-projects after selection	Party involved	x	x	x
Safety area Rotterdam-Rijnmond	Involve in initial planning initiatives	Party involved	x	x	x
Local community Rotterdam	Involve in urban debate on future Vierhavens/ **RCC** Inform on progress of project	interested	x	x	x
Universities and schools	Offer place for trainees interns Initiate and perform pilot projects, experiments, (new) interpretations, innovation etc.	interested	x	x	
Cities with same issues (Hafencity Hamburg, London Thames Gateway and VS/Canada)	Organise knowledge and experience exchange meetings and excursions	interested	x	x	x
Other interested parties	Inform on progress of project	interested		x	x

2.2.2 Stakeholders for Balance 4P workshops

Balance 4P three workshops were planned but only two were carried out. The third workshop was replaced by an investigation on subsurface information transfer in tender documents.

Workshop 1

The first workshop was a broad workshop on chances and challenges from the subsurface on the aboveground development. This workshop was about the whole area with people from:

- project bureau M4H ("aboveground experts");
- engineers of the municipality of Rotterdam ("subsurface experts");
- researchers from Balance 4P project (the Dutch parties: Deltares, TUD and an attendee from VITO from Belgium and an attendee from Chalmers University of Technology from Sweden);
- a student doing an internship at the municipality.

Workshop 2

The next workshop aim at specific areas within Merwevierhavens and on specific themes within this area. Because the following workshop have a content based character, the stakeholders involved do not necessarily need to represent the broad group involved in making decisions and being affected by decisions. For the aim and character of the workshops it was decided that a specific subgroup should be involved. Also note that in both workshops there are only representatives of the first three of the four main stakeholder groups identified in Balance 4P involved.

1. "knowledge" (knowledge institutes, universities);
2. "regulators" (the different fields of regulation (environment, city planning, social and economic affairs) from municipality, region and environmental agency);
3. "business" community (advisors, housing corporations, utility companies);
4. "society" (social initiatives).

In Rotterdam, involvement of social initiatives in the workshop was not found appropriate in this phase by the municipal development bureau. However, they have contacts with the local community in their on-going projects (e.g. in an urban farming project in the Merwevierhavens). In the second workshop the companies on site are involved. Currently there are no people living on the actual site and due to the stagnating development as a result of the economic crisis, it is not yet clear what the future functions will be. Thus, at this moment, the local community was not a primary stakeholder for the municipal development bureau.

Workshop 2 looks at the central area (Figure 2-5) with terrains of:

- E.ON;
- Former gas plant Keilehaven;
- Eneco/Ferro.

The workshop was focused on themes civil constructions (incl. soil: remediation) and energy concepts. In Table 2-3 relevant stakeholders for this workshop are identified and characterized.

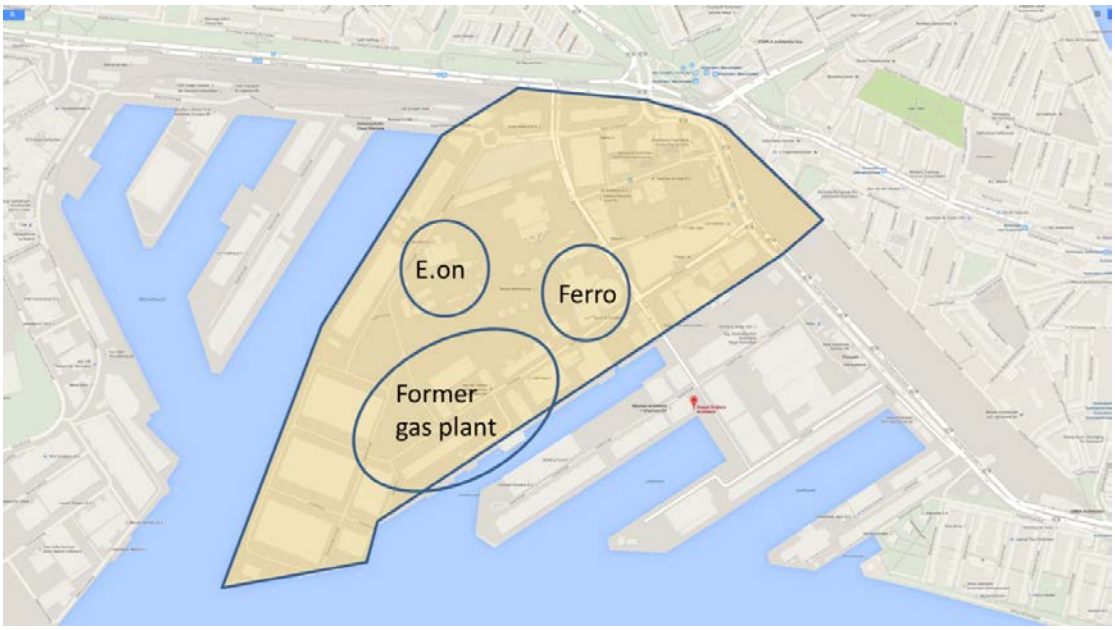


Figure 2-5. Focus area Balance 4P for workshop 2.

Investigation on subsurface information transfer

The third stakeholder activity was to look into the information transfer between the municipality and the developers or constructors. The investigation was done on tender documents in which the municipality is setting out a development or construction plan for a part of an area or infrastructure to market parties. Analysing existing documents, and in consultation with subsurface experts, a proposal was made on how subsurface information can be integrated better. Table 2-4 presents the stakeholders that should be approached in the investigation.

Table 2-3. The stakeholder analysis result for workshop 2.[2]

GROUP	GROUP'S INTEREST IN ISSUE	RESOURCES	RESOURCE MOBILIZAT. CAPACITY	POSITION ON ISSUE
1. Eneco	energy concepts	Expertise, leverage, invest.	Not checked	Not checked
2. Warmtebedrijf	energy concepts	Expertise, leverage, invest.	Not checked	Not checked
3. Eneco	energy concepts	Expertise, leverage, invest.	Not checked	Not checked
4. Warmtebedrijf	energy concepts	Expertise, leverage, invest.	Not checked	Not checked
5. Ferro	Current land user	leverage	Not checked	Not checked
6. Stedin (Cables and pipes)	Manager cables and pipes present in area (land user)	Expertise, leverage	Not checked	Not checked
7. Port of Rotterdam	Current land user	Leverage, investment	Not checked	Not checked
8. Municipality Rotterdam, subsurface experts: archaeology, geotechnical, geohydrology / foundations, cables and pipes	Balance 4P project (research)	expertise	quick	++
9. Project leader project bureau M4H Urban planner Landscape architect	Leader of redevelopment, Balance 4P project (research)	Decision maker, expertise, leverage, budget	quick	++
10. TUDelft 11. Experts energy 12. Urban planning	Balance 4P project (research)	expertise	quick	++
13. Deltares 14. Experts soil, remediation, geotechnical aspects	Balance 4P project (research)	expertise	quick	++
15. Students TUD	Balance 4P project (research)	expertise	quick	++

[2]

- Group's interest in Issue: those interests that will be affected by the decision to be taken (just the most important ones);
- Resources: the resources the group possesses that can be used in the decision making. (knowledge, information, leverage, money);
- Resource Mobilization Capacity can the group mobilize these resources quickly or slowly? This is important when looking at the dynamics of the decision making. If a decision needs to be taken quickly, but the resource (eg knowledge) can only be delivered slowly, this resource is of less importance than previously thought;
- Position on issue. The position should be examined. People can be strongly negative (- -), slightly negative (-) or slightly positive (+) or completely positive (+ +).

Table 2-4. The stakeholder analysis result for the investigation on subsurface information transfer.

GROUP	GROUP'S INTEREST IN ISSUE	RESOURCES	RESOURCE MOBILIZAT. CAPACITY	POSITION ON ISSUE
1. Port of Rotterdam	Current land user	Leverage, investment	Not checked	Not checked
2. Municipality Rotterdam, subsurface experts	Balance 4P project (research)	expertise	quick	++
3. Project leader project bureau M4H Urban planner Landscape architect	Leader of redevelopment, Balance 4P project (research)	Decision maker, expertise, leverage, budget	quick	++
4. Strategis	Service provider for the M4H project	Expertise,	quick	Not checked
5. TUDelft 6. Experts energy 7. Urban planning	Balance 4P project (research)	expertise	quick	++
8. Deltares 9. Experts subsurface	Balance 4P project (research)	expertise	quick	++
10. Students TUD	Balance 4P project (research)	expertise	quick	++

2.3 Generation of redevelopment alternative(s)

For this case, two workshops and an investigation were performed within the project:

- Workshop 1: Broad workshop using System Exploration Environment & Subsurface (SEES) methodology (see Box 2.1 for description of SEES);
- Workshop 2: Specific workshop on Ferro, Eneco area;
- Investigation: focus on data & information.

Box 2.1. System Exploration Environment & Subsurface

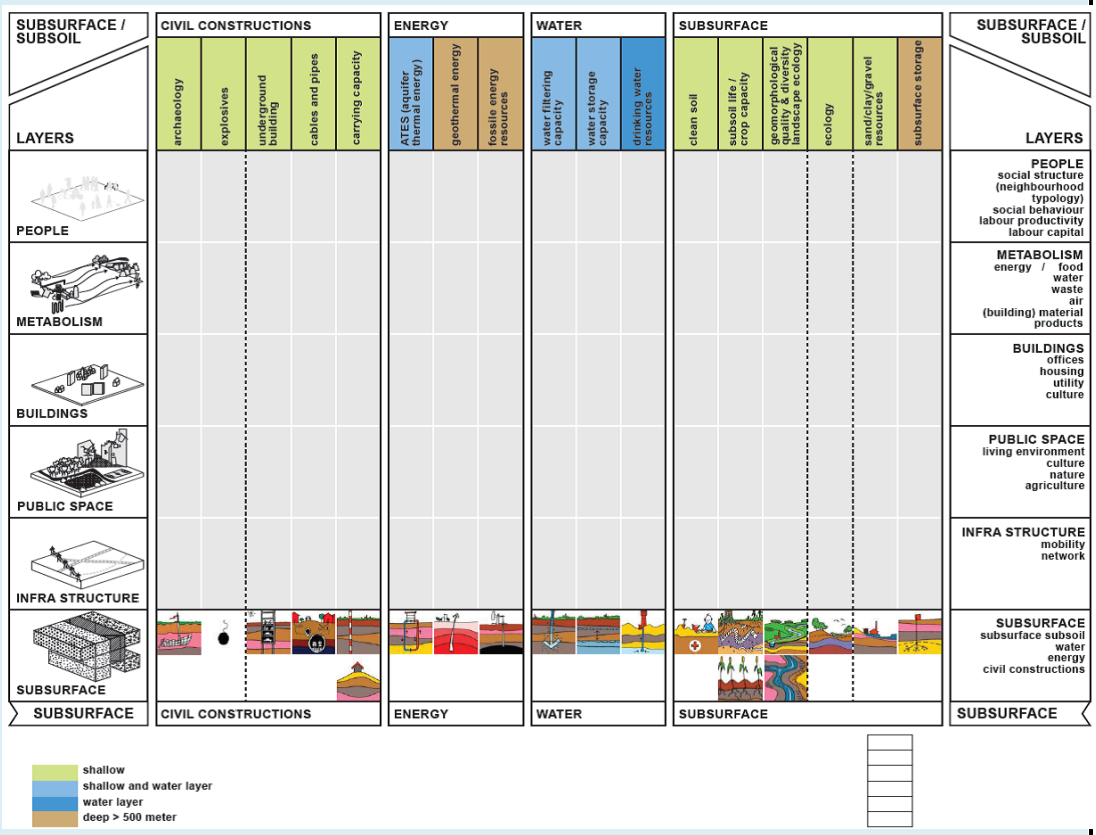
SEES

For a systematic analysis of the risks and opportunities for brownfield redevelopment related to the characteristics of the environment and specifically of the subsurface, the method System Exploration Environment & Subsurface (SEES) was used in the case studies.

SEES is a method which supports and registers the knowledge exchange between experts of different fields. The method gives an overview of the urban system: it relates the "above ground" layers of people, cycles (metabolism), buildings, public spaces and infrastructure to "subsurface qualities" divided in four themes: civil constructions, water, energy and soil. The method is related to the Japanese LEAN thinking as developed by Toyota (Womack & Jones, 2003). LEAN thinking avoids making mistakes. This is done by not focussing on impossibilities but on quality, direct communication and making and keeping clear agreements. The System Exploration Environment & Subsurface method enables smarter

producing of (re)development designs if it is performed in an early stage of a (re)development process.

The SEES method is meant to be used in project teams working on urban development. It guides the dialogue between the representatives of the technical and natural boundary conditions and the aboveground specialists that represent the social-economic requirements. It offers a systematic overview that enables the consultation of all necessary specialists and fields and gives opportunity to search for clever connections. Because the subsurface is taken into account and all information is being gathered and discussed in a systematic way during the planning process, it is possible to make smarter urban designs. Smarter urban designs lead to more climate proof (think about the water issue), to energy-saving (storage and extraction of subsurface warmth and cooling water), more sustainable (the identification of cycles) and to cheaper (earlier identification of benefits, problems and costs) designs.



System Exploration Environment and Subsurface (SEES) matrix

What is needed?

1. Large print of the System Exploration Environment & Subsurface matrix;
2. Chairman (m/f) who keeps track of the time and asks questions;
3. The stakeholders / specialists of all layers (urban designer, project leader, landscape architect, traffic expert, housing corporation, plan economist, archaeologist, cable and pipe expert, water-, energy-, soil experts etc.);
4. Site-specific information from the stakeholders / specialists for the project area.

How it works:

1 The panel chairman gives an introduction of the SEES method (10 minutes);

2 Each participant introduces him- or herself and indicates his/her domain in the system that is presented in the matrix (15 minutes);
3 Aboveground experts give an explanation about the characteristics of the area, the social-economic ambitions and the plans (15 minutes);
4 Go through the natural and technical boundary conditions in a systematic way with (this is presented by the subsurface experts, per theme):
   - Civil construction: Archaeologist, specialists on explosives (when expected);
   - Cables and pipes and geotechnical information in relation to subsurface building;
   - Carrying capacity;
   - Energy: ATES (Aquifer Thermal Energy Storage) and Geothermal energy specialists;
   - Water: Geohydrological and water management specialists;
   - Soil: soil experts and ecologist.
5 Start a conversation about the opportunities, obstacles, points of attention and boundary conditions;
6 Make connections between themes: enter the highlights in the system exploration;
7 When all subsurface qualities are discussed, they can be evaluated per aboveground layer.

The SEES method is available for download and use from
https://publicwiki.deltares.nl/display/SEES/HOME+English

What is the result?

- An overview of opportunities, obstacles, points of attention and boundary conditions for development of the area;
- Possibilities for cheaper, climate proof and sustainable development options;
- Contact between all necessary stakeholders and specialists;
- A dialogue, in which the specialists from the aboveground and subsurface are involved and have the opportunity to understand each other.

When to use SEES?

In all phases of the redevelopment the SEES method can be used. However, in the earlier phases of the initiative and the planning and design phases the beneficial effects of the method are greater.

2.3.1 Workshop 1: Broad exploration

The main questions for this workshop were: what are the innovative possibilities for the subsurface in relation to the aboveground developments. How can we integrate the subsurface in the development strategy? The main objective was to identify the chances and challenges from the subsurface (both soil, subsurface and sediments) in relation to developments aboveground. The System Exploration Environment and Subsurface (SEES) was applied to this end. Different experts from the subsurface and development groups from the Municipality and Port of Rotterdam were present.

The main challenges and points of attention for the redevelopment were:

- Transformation from harbour to residential area (> 2025);
- Function as engine for new economy. Strong points of Rotterdam, (including environment and education) are Cleantech, Food, and Health;

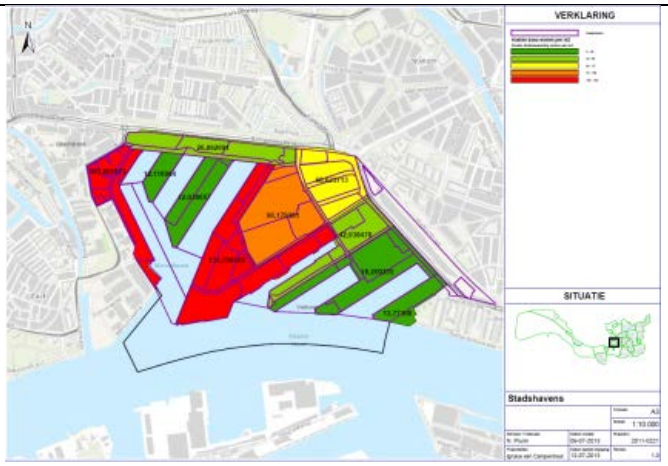
- The area team of the Port and the Municipality of Rotterdam has as an objective that current businesses should be able to keep functioning and should transform in time;
- Mainly ground lease contracts, ownership with municipality or port of Rotterdam;
- Organic transformation of the area: change piece by piece;
- How can we connect the subsurface and the aboveground functions?
- Specific points of attention: contamination, the area outside the dikes, hard quays, and limited green space;
- Do not think in problems but in possibilities when looking at the characteristics of the area. If subsurface is not considered now, it will be too late;
- For the aboveground, the (plan-economic and strategic) data is gathered in "StrateGIS" (such as costs for buying or leases). Chance to also integrate subsurface data in 1 system (such as soil exploitation, prepare sites for building, remediation, archaeological expectation, cables and pipes, unexploded ordnance (UXO), quays etc.);
- There is much information on the subsurface, but it needs to be translated so it becomes interesting and approachable for the redevelopment (e.g. effect on costs for developments in an area).

Subsurface aspects

The topics civil constructions, energy, water and soil are of importance in the Merwevierhavens area and were presented in the workshop. In the workshop, the chances and challenges were identified by the attendees from above- and underground (see Table 2-5).

Table 2-5. Underground aspects of importance for M4H Rotterdam.

CIVIL CONSTRUCTIONS:	
• Archaeology (old dike) • Cultural historical value (some buildings) • Structures in subsurface (cellars, fundaments, quay walls) • Unexploded ordnance (UXO) • Cables and pipes (many)	 Archaeology

ENERGY	
• ATES (potentially, no systems yet) • Geothermal energy (potentially, interesting) • Gas/oil (not economically interesting) • Use temperature from harbour activities	 Heat network
WATER	
• Groundwater (contamination, no drinking water) • Mixed seepage / infiltration (tidal)	
SOIL	
• Contamination • Elevation 5-3,5 m +NAP[3] • Ecology (potentally interesting area, sandy soils, quay walls)	 Costs for remediation for residential use

The following aspects (both chances and challenges) for further research were selected as result of the workshop (and used as input for the next workshop):

Organic redevelopment

- Fast redevelopment of the west piers, the centre can be redeveloped as one large area. In the east, small areas with recreation and connection to the other side of the river (Heijplaat, RDM area);
- Development of higher segment or mixed, parks, residential, parks and working areas;
- Look at smaller and larger scales (use, energy, maintenance);
- Look at long and short term for companies (infrastructure, demand for resources);
- Start with “easy” star locations, to begin the redevelopment (oil stain effect).

Soil quality

- Remediation of the gas factory can be the start of the redevelopment of the area;

[3] Normaal Amsterdams Peil or Mean Sea Level

- Location of the environmental facilities.

Green

- Greening the area;
- Green quays, as special attraction (ecological value);
- Connect the close by “Roof park” (Figure 2-6) with green infrastructures to the river.

Subsurface opportunities

- Lay a spatial framework over the characteristics of the subsurface. Use the landscape as a carrier for the development of the area (contamination, infrastructure, and climate);
- Investigate other ways of making fundaments, reuse quays, or old fundaments;
- Which cables and pipes are still usable for other purposes at the E.ON area?

Water

- Options for reuse. Sewerage? Waste water? Disconnect from sewerage system?
- Recreation in surface water;
- Metabolism: reuse / regain minerals / nutrients in experimental lab. Compost – sewage water – floating crops.

Energy

- Energy concepts, Smart energy grid, Energy tower;
- Geothermal energy, E.ON as energy hub for heating the city;
- Caissons /tidal energy?;
- Investigate energy options (area typology, demand and supply scenarios);
- Caissons, development (osier-land, biomass).

Figure 2-6. On a former shunting-yard has in 2013 the Roof park Rotterdam opened, the larger roof park of Europe. By applying green area on the rooftop of shopping malls, 80.000 m2 of park is added to the city (Schaeken et al, 2014).

Figure 2-7 presents the results from the first workshop in the SEES matrix.

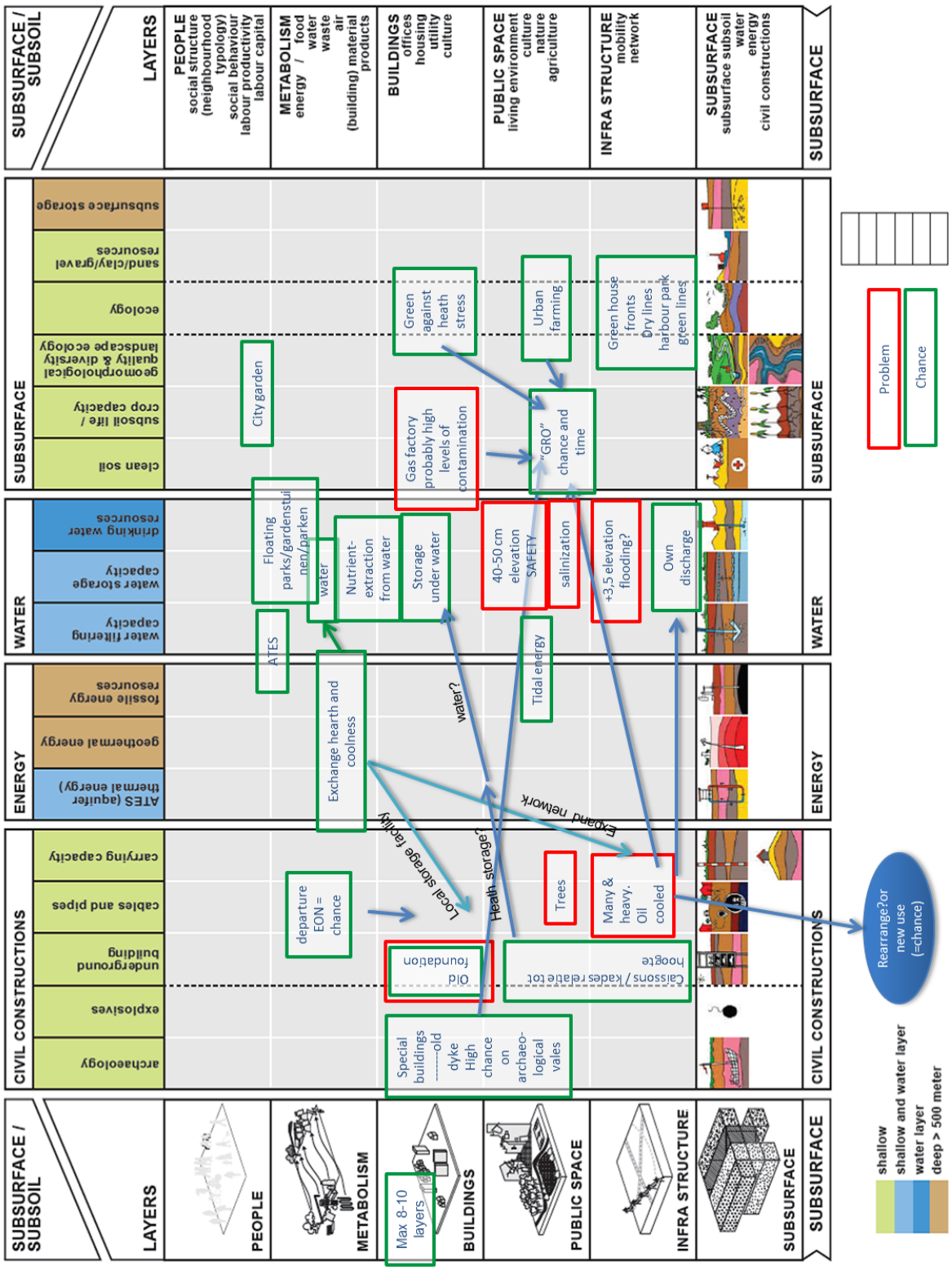


Figure 2-7. Results of workshop 1 of Merwevierhavens, Rotterdam, The Netherlands.

2.3.2 Workshop 2: FERRO- E.ON-Eneco-ENECO area

As a result of the first workshop, the centre area with E.ON, Eneco, Ferro was chosen to investigate in greater detail by means of the SEES matrix. (see Figure 2-8). The remediation of the gas factory (for which there is budget reserved from the national government) can be the start of the redevelopment of this area. Further, there has already been some "movement" in this area: the FERRO gas holder will be transformed into a music podium in December 2014. This can be a star location, where the redevelopment begin and consequently make the area more attractive for other investors.

Figure 2-8. The central area with the former gas factory.

The main focus for this workshop was on the following subjects:

1. Civil constructions: interferences between fundaments, archaeology, cables and pipes, related to contamination.
   From workshop 1:
   - Investigate other ways of making fundaments, reuse quays, or old fundaments;
   - Which cables and pipes are still usable for other purposes at the E.ON area?
2. Energy concepts that can be realized when E.ON is seen as an energy hub for the whole city.
   From workshop 1:
   - Energy concepts, Smart energy grid, Energy tower;
   - Geothermal energy, E.ON as energy hub for heating the city;
   - Caissons /tidal energy?
   - Investigate energy options (area typology, demand and supply scenarios);
   - Caissons, development (osier-land, biomass).

The current situation and subsurface possibilities at E.ON/Eneco/Ferro area were prepared before the workshop, see Figure 2-9.

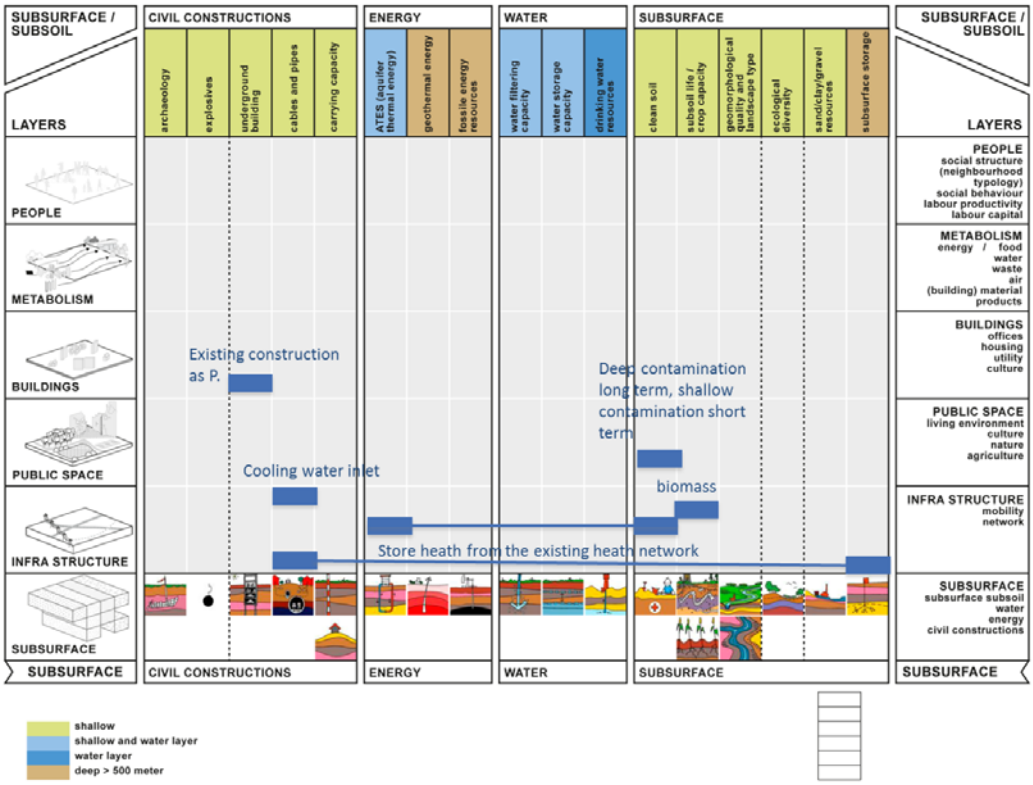


Figure 2-9. The current situation and subsurface possibilities at E.ON/Eneco/Ferro area.

In addition, before the workshop three scenarios were outlined, based on the choices that can be made for environment (mobile contamination deep, immobile contamination shallow), archaeology, cables & pipes (C&P), fundaments & quays, summarised in Figure 2-10.

1. Long term: 30 year monitored natural attenuation (NA)
   In 30 years new functions / transition, when a function ceases, it will be renewed. Clean area during temporary and cultural use of the area. Example = Emscherpark, Germany. Earn with geothermal source. Link to heat network. Gives the character of a modern energy hub, future for heat supply. Green cultural function for area and city. “Brand” the location, for future use when residential area is built. Options for flexible temporal housing, container housing;
2. Mid-term: 7 year stimulated NA
   7 years Stimulated NA. Continue current use. Transform areas that become available and assess per site what the most suitable / feasible use is. Different forms of energy, mixed use. Use piers and reuse fundaments. Make public facilities suitable for businesses and housing (green, infrastructure);
3. Short term: now remediate/ dig & dump
   Clean everything up when possible. Right scale and quality for intensive residential area. Energy park.

Further choices within the scenarios are:

- Archaeology: the options are to excavate or remain;
- Fundaments options: quays reuse, pinch off (half remove), start over (new);
- Cable & Pipe: options excavate or reuse;
- Energy options: ATES, geothermal energy, water surface decentralized;
- Remark: ATES can be combined with monitored natural attenuation MNA / NA.

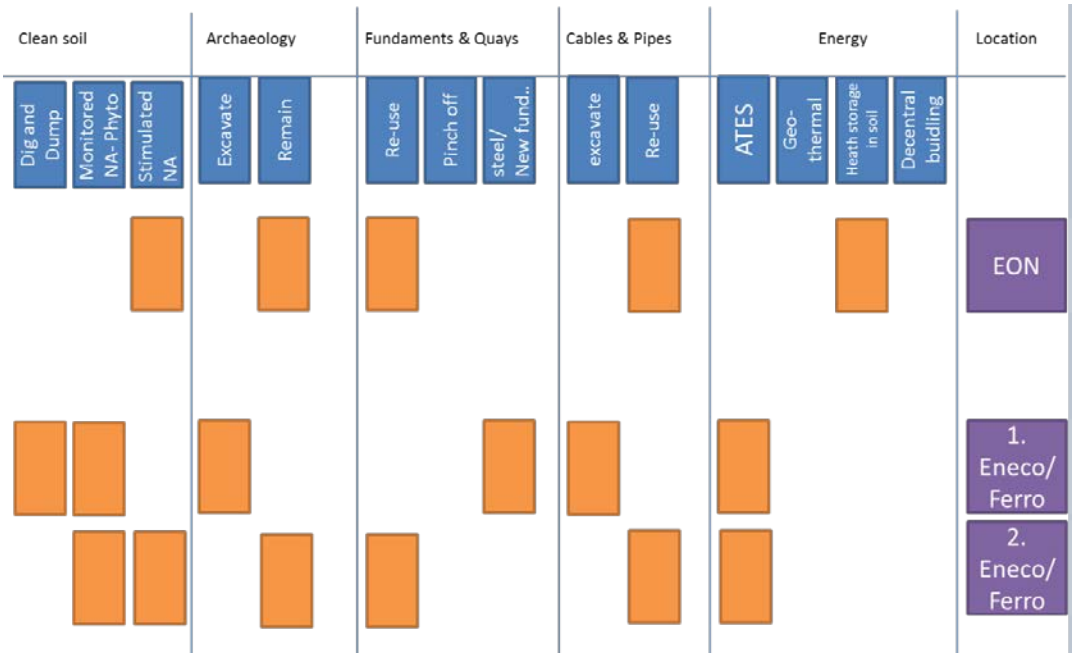


Figure 2-10. Options for the redevelopment of E.ON/Eneco/Ferro area, taking into account contamination, archaeology, fundaments & quays, cables& pipes, energy. NA: natural attenuation. ATES: aquifer thermal energy storage.

During the workshop the different scenarios were discussed. Although short term remediation might be good to start redevelopment with a clean sheet, it is not feasible in the current economic environment. There is some tension between short and long term decisions. However, there are chances for organic developments, development of an experimental area for different innovative concepts. The results of the workshop are presented in an "idea book" (Appendix A). An example of the outcomes can be found in Figure 2-14 in relation to reusing quays or old fundaments, see Section 2.5.

The scenarios used in the workshop helped the discussion. The starting points (contamination and subsurface structures) as defining aspects for the use of space and related time and costs worked well to make people conscious of the dimension of the subsurface. Beforehand, the potential benefits of the subsurface for the redevelopment (such as ATES, Archaeology) were never considered, because typically they are unknown. A gain of the project this far was that the aboveground people had broadened their vision towards the subsurface, as a result from the first workshop. During the

second workshop, they started to ask specific questions on the consequences and costs of subsurface aspects for different development options.

A point of attention that arose from the second workshop was the data availability on private areas. A lot of information on the subsurface (mainly cables and pipes) was not known by the municipality. This was a gap in the preparation of the workshop. The data was brought by the companies, but could have been used more effectively had they been known before.

2.3.3 Investigation: Focus on data & information

As already discussed for the first workshop: information on the subsurface is of importance. There is a lot of information, but it needs to be available and translated so the information gets meaning for the (aboveground) redevelopment (e.g. effect on costs for developments in an area). For the aboveground, the (plan-economic and strategic) data is gathered in "StrateGIS" (such as costs for buying or leases). There is a chance to also integrate subsurface data in the same system (such as soil exploitation, prepare sites for building, remediation, archaeological expectation, cables and pipes, unexploded ordnance (UXO), quays). Instead of arranging a third workshop, an investigation was carried out on the role of data and information. The aim was to detect where subsurface can be integrated in the "products" that were produced for the redevelopments: the tender documents (in this case for another harbour area within the city harbours: Rijnhaven) and the draft development strategy (Stadshavens Rotterdam, 2013-I, 2013-II, 2014). The investigation was done together with StrateGIS, who has developed different tools to gather and open up data /information for redevelopment projects, e.g. the tool "Gebiedsontwikkelaar" (in English: "area developer"), see Box 2.2.

Box 2.2. Gebiedsontwikkelaar.

Gebiedsontwikkelaar ("area developer")
The Gebiedsontwikkelaar is a 3D software tool that can be used for making feasible spatial plans.

What is needed?
Data and information on property value, existing buildings, value of buildings, benchmarking on spatial use functions, databases met financial real estate characteristics and calculation models for soil and real estate exploitation. This can be extended with "translated" subsurface data with meaning for the spatial developments (e.g. remediation costs for specific future functions).

How it works
The Gebiedsontwikkelaar processes the above data and information and shows potential scenarios on a well-organized manner. The build-in check on urban design principles helps the user by making a realistic plan. It is a plug-in of Sketchup© (3D model package). The software is compatible with existing GIS– and CAD systems and is available under licence.

What is the result
The result of this module is that the user in one glance gets clarity in the relations between current cadastral and topographical situation, the planning framework (e.g. zoning plans) and the future program from an urban or landscape plan. The discussion on boundary conditions for the plan can be held efficiently. It is possible to calculate different programs roughly or in detail.

When to use Gebiedsontwikkelaar
Gebiedsontwikkelaar can be used in large complex spatial developments, such as the (re)development of an area or district.

A meeting with the municipality, StrateGIS, TUDelft and Deltares took place to investigate the role of subsurface data and information within the tender process for the redevelopments towards market parties. Underneath the results from the meeting is presented.

A gap in data availability between public and private space was identified. The municipality has spent a lot of effort in subsurface data gathering (since the 70s) but when private areas are given back to the municipality for redevelopment, a lot of information is missing, e.g. data on cables and pipes. The private owners sometimes have the data, but it is not necessarily transferred to the municipality when the area is handed over. Furthermore, when the private owner has data it is not known which subsurface data. To get a better picture on available data, much more efforts have to be made. One possible solution is that the subsurface situation is 'measured' when areas are given out to private parties and when they are given back to the municipality on multiple aspects. The municipality is responsible to make the sites ready for building, the aspects that belong to this task could be included in the measurement when transferring sites. Now this measurement is only done for the soil and groundwater quality, and sometimes fundaments, but this could be expanded to cables and pipes.

On information the motto is: the clearer the better. It is also important to indicate where data is uncertain, not known or when the quality is doubted. When the municipality indicates such gaps in the data, private parties might be stimulated to fill in the gaps.

The information on the subsurface can be brought into the development process by offering this data in the products that are produced for the (re)development: e.g. the visions or the tender documents. This was done for the draft vision document of Merwevierhavens and the tender documents Rijnhaven (Stadshavens Rotterdam, 2013-I, 2013-II, 2014).

The data can be enclosed by tools such as the "Gebiedsontwikkelaar" (Box 2.2) or other visualisation tools such as the soil tool[4] of StrateGIS. The next step is to expand the "Gebiedsontwikkelaar" with subsurface data and information, such as costs. The idea is that it is possible to point out a specific area in the sites and to get an overview of all relevant subjects (and what they mean for the development) in the above- and underground. The municipality of Rotterdam and StrateGIS will work further on this expansion in 2015 (the results are not taken up in this report).

2.3.4 Student work

In addition to the activities with the municipality described in previous sections, students from the Technical University in Delft have used this area in a workshop and for design tasks. The following activities were carried out with and by students:

- An interdisciplinary student workshop (30 students) (May 8-9);
- Two HOMBRE 5 tools were applied by students on the area, giving redevelopment options:
  - Brownfield Remit/Response (BR2) tool (Ramkisor, 2014; see Box 2.3 for description of BR2);
  - Brownfield Opportunity Matrix (BOM) for soft Reuse (Gogh, 2014; see Box 2.4 for description of BOM);
- Two students carried out project designs on the basis of the results of the workshop;
- One student did a graduation project and internship with the municipality of Rotterdam.

All student reports are available on request.

Box 2.3. Brownfield Remit/Response (BR2) tool

BR2 is a method to "provide a means for exploring the impact that brownfield redevelopment will have on the urban system within which it takes place and the exploration of the consequences that will arise as a result of these impacts. Therefore, it can provide a means for selecting redevelopment options based on site specific analysis of the impact of redevelopment rather than relying on generic theories of redevelopment (i.e. building employment generating buildings will reduce local unemployment). In this way it provides a means to select redevelopment options using a robust evidence based approach" (Leney & Nathanail, not dated).

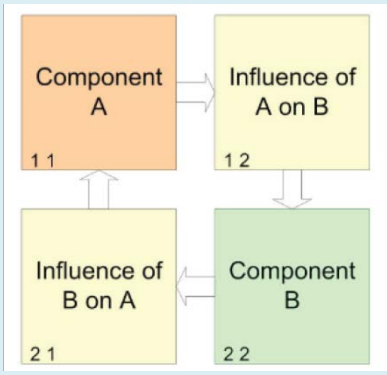
A system is a group of elements forming a connected or complex whole (Simpson et al, 1989). Traditional approaches that assess the impact of redevelopment assume that the urban system is a simple system and that causes and effects are directly linked. These ways of approaching redevelopment impacts exclude a lot of relations and indirect causes and effects. BR2 treats the urban system as a complex and interactive system that will respond in a dynamic way to change. Within a system like this simple changes can result in unexpected, and possibly undesirable, outcomes. By applying a systems approach, the planned redevelopment options can be assessed on site specific analysis of the impact of redevelopment using a robust evidence based approach rather than relying on generic theories of redevelopment (Leney, 2008, pg. 120-121). The method is based on

[4] www.Strategissoftware.com/geoviewer
[5] HOMBRE - Holistic Management of Brownfield Regeneration: http://www.zerobrownfields.eu/

REMIT/RESPONSE, a procedural approach to rock engineering that applies existing knowledge about a rock mass to develop a model of a rock engineering situation which can then be used to develop procedures to deliver stated objectives (Hudson, 1992; Nathanail et al., 1992).

What is needed?

Expert knowledge of the area and the aspects that are considered.



How it works:

The BR2 tool works via a matrix - an N2 chart - that models the urban fabric of the city. The matrix is build-up out of squares representing the fabric and its functioning (see inserted simplified figure). The diagonals from the top left corner to the right bottom form the important elements e.g. housing stock, transportation, biodiversity etc. Each other square is horizontally and vertically linked to two components and describes the relation between the first and the second one. An interaction matrix can be tailor-made for every specific site. The methods used to do so are expert judgment and winnowing. With the first method a group of expert and stakeholders can determine which elements are relevant and important enough to be a leading diagonal. The second method is a more systematic process. Winnowing, in this context, means discarding the irrelevant. The theoretical process is to start with a coarse matrix with 3 or 4 very general elements, e.g. natural environment, built environment, policy and finance. Then the elements which do not seem relevant are winnowed out (unlikely in the first stage). Next each element is expanded into several sub-elements, followed by winnowing out any of these that are not relevant to the site and surrounding area. This process is continued until the user is content with the matrix. The BR2 tool is available for download and use from the Brownfield Navigator[6].

What is the result?

- More insight in the urban system;
- An overview of interrelationships between aspects to be used in the development of the area;
- An overview of dominant and subordinate aspects;
- Contact between stakeholders and specialists;
- A dialogue, in which the specialists are involved and have the opportunity to understand each other.

When to use BR2

The BR2 tool can be used in the planning and design phase, in an early stage to explore the system and in a later phase to create scenarios.

[6] bfn.deltares.nl

Box 2.4. Brownfield Opportunity Matrix

Soft end uses of brownfields, such as biomass or green space, can provide services which add value to a regenerated site, both in their own right and integrated with hard uses such as for buildings. The "Brownfield Opportunity Matrix" (BOM) is a MS Excel based screening tool to help decision makers identify what services they can get from soft reuses and so add value to a regeneration project. It maps desirable services with the interventions (e.g. treatments) that can deliver these services for their site, as shown in broad terms below.

Services	**Interventions**
• Risk Mitigation of Contaminated Land and Groundwater • Soil Improvement • Water Resource Improvement • Provision of Green Infrastructure • Mitigation of Human Induced Climate Change (global warming) • Socio-Economic Benefits	• Soil Management • Water Management • Gentle Remediation Options • Other Remediation Options • Implementing Green Infrastructure • Renewables (energy, materials, biomass) • Sustainable Land Planning and Development

As well as mapping desirable services against the interventions that can deliver them, the BOM:

- Assists identification of the most effective combinations of available interventions;
- Provides initial guidance on likelihood of success and technical feasibility;
- Describes the types of value that can be generated;
- Provides links to high level operating windows that describe technical suitability and sustainability drivers and to provide links to more detailed information;
- Provides links to high level opportunity windows that give examples of successful deployments of interventions to provide particular services.

Overall it plots the value of applying the Interventions either on their own, or in combination with other interventions. The goal of the matrix is to encourage redevelopment of Brownfield land so that it re-enters the land-use cycle. The matrix is intended for use by land owners / managers, potential investors, local authorities and government stakeholders and especially for brownfields where the market mechanism is working less well.

What is needed?

Stakeholders that are willing to look at different possibilities for BF sites, provided by soft uses

Data on site characteristics to determine required services and boundary conditions for application (operation windows).

How it works:

The matrix can be used to map the range of opportunities (and hence value) that might be achieved from a brownfield regeneration project and the project's consequent sources of value, as shown below. It also provides supporting information to describe the various services, interventions and opportunities listed in the matrix. Overall the Brownfield Opportunity Matrix is a versatile tool which can:

1. Support initial identification or benchmarking of soft re-use options for brownfields at an early stage, for example where a landowner is just beginning to consider options (pre-exploratory stage);
2. Shows the types of interaction between service and intervention (see below);
3. Support exploratory discussions of an initial concept with interested stakeholders' options (exploratory stage);

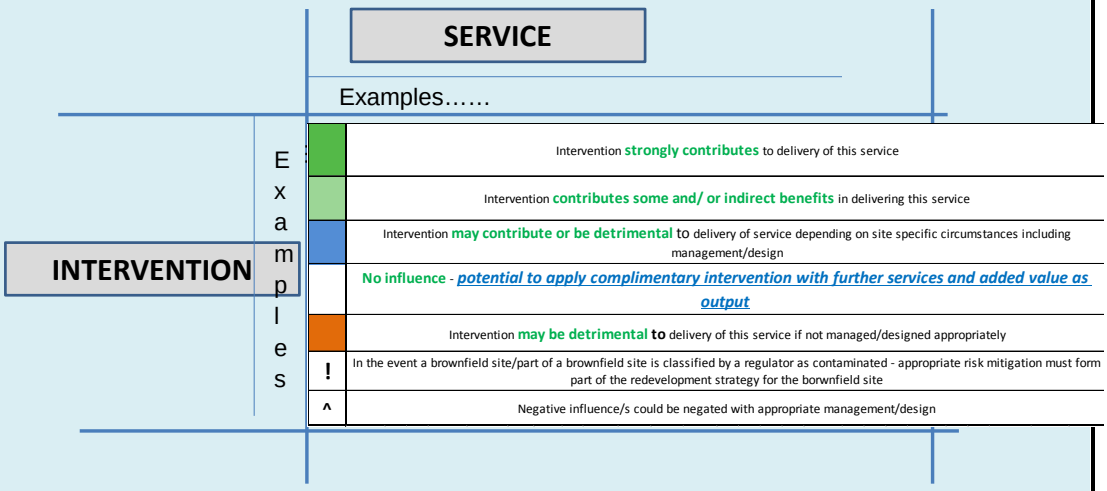
4. Provide a framework to describe an initial design concept, in support for example of planning applications options (exploratory stage);
5. Provide a framework for more detailed sustainability assessment of different re-use combinations, and similarly for cost benefit comparisons.

	Intervention **strongly contributes** to delivery of this service
	Intervention **contributes some and/ or indirect benefits** in delivering this service
	Intervention **may contribute or be detrimental** to delivery of service depending on site specific circumstances including management/design
	No influence - ***potential to apply complimentary intervention with further services and added value as output***
	Intervention **may be detrimental to** delivery of this service if not managed/designed appropriately
!	In the event a brownfield site/part of a brownfield site is classified by a regulator as contaminated - appropriate risk mitigation must form part of the redevelopment strategy for the borwnfield site
^	Negative influence/s could be negated with appropriate management/design

The BOM Excel file is a mapping matrix listing services from interventions (see schematic below)

- Showing in a table where there are strong associations, potential associations, associations that depend on site specific circumstances, potential antagonisms (see schematic below);
- Showing types of value outputs in the same table;
- High level operating windows linked from interventions listed in the table;
- Opportunity windows linked from the matches shown in the table;
- Service descriptions to provide more information about potential services.

The BOM supports a process of optimisation whereby stakeholders can discuss the integration / combination of interventions that maximise services, and hence value using interventions that are synergistic or complementary.



The BOM is available for download and use from the Brownfield Navigator[7], which also includes tools for describing and note taking on a geo-spatial basis the various interventions and their opportunities. It can work with the BR2 tool, by using initial BR2 assessments to

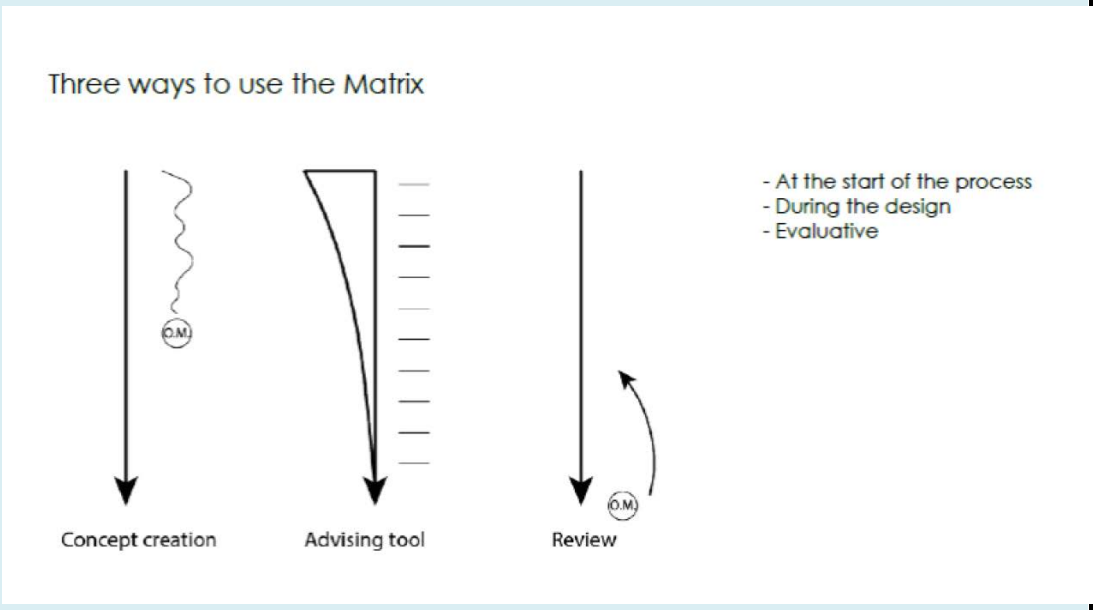
[7] bfn.deltares.nl

identify key driving forces for service requirements. The outputs of the matrix can also be fed back into the BR2 tool to describe a post regeneration status for the site.

What is the result?

- More insight in possibilities for soft reuse and services / benefits delivered;
- An overview of pursued services delivered by soft uses;
- An overview of interventions needed to acquire pursued services;
- Contact between stakeholders and specialists;
- A dialogue, in which the specialists are involved and have the opportunity to understand each other.

When to use BOM



2.4 Assessments of project redevelopment alternatives

In the Rotterdam case, the emphasis is on developing sustainable urban design integrating the subsurface. In this case study, this was explored in-depth and assessments of alternatives were not performed.

2.5 Synthesis

The main questions of the program bureau were: What are the innovative possibilities for the subsurface in relation with the aboveground redevelopment? How can we use subsurface in the development strategy? How can we make the subsurface operational in day-to-day urban development practice?

The workshops and student work gave several results and options for the area (e.g. investigating alternative ways of reusing old quay constructions, Figure 2-11, and creation of a subsurface potential map, for different scales, Figure 2-12 and Figure 2-13). It will be an organic development, over a longer time span. However, using the subsurface situation as a framework was found to be a good starting point.

Points of attention identified were especially: the contamination situation and possible presence of UXO and the positions outside the dikes (water safety issues) when planning new uses; chances of taking advantage of the archaeological situation (make old dyke visible), re-use of fundaments, quays and cables and pipes for different options; green should play an important role in the future use; in the centre part (E.ON, Eneco, Ferro) consider that there is room for energy concepts. These is illustrated by Figures 2-14, 2-15, 2-16 and 2-17.The results are gathered in an idea book in Appendix A.

For the development strategy the project results are directly used to give advice in how to make the subsurface also present within the vision. The urban development vision often is about function and future of these functions. When the characteristics of the location as a quality or also as boundaries is taken in from the start it is known and accepted. From then on it is easier to take it along in the day-to-day development. For that last question a series of maps is produced that identifies the subsurface as base of the developments and shows what chances and boundaries are (see Figures 2-14, 2-15, 2-16 and 2-17).

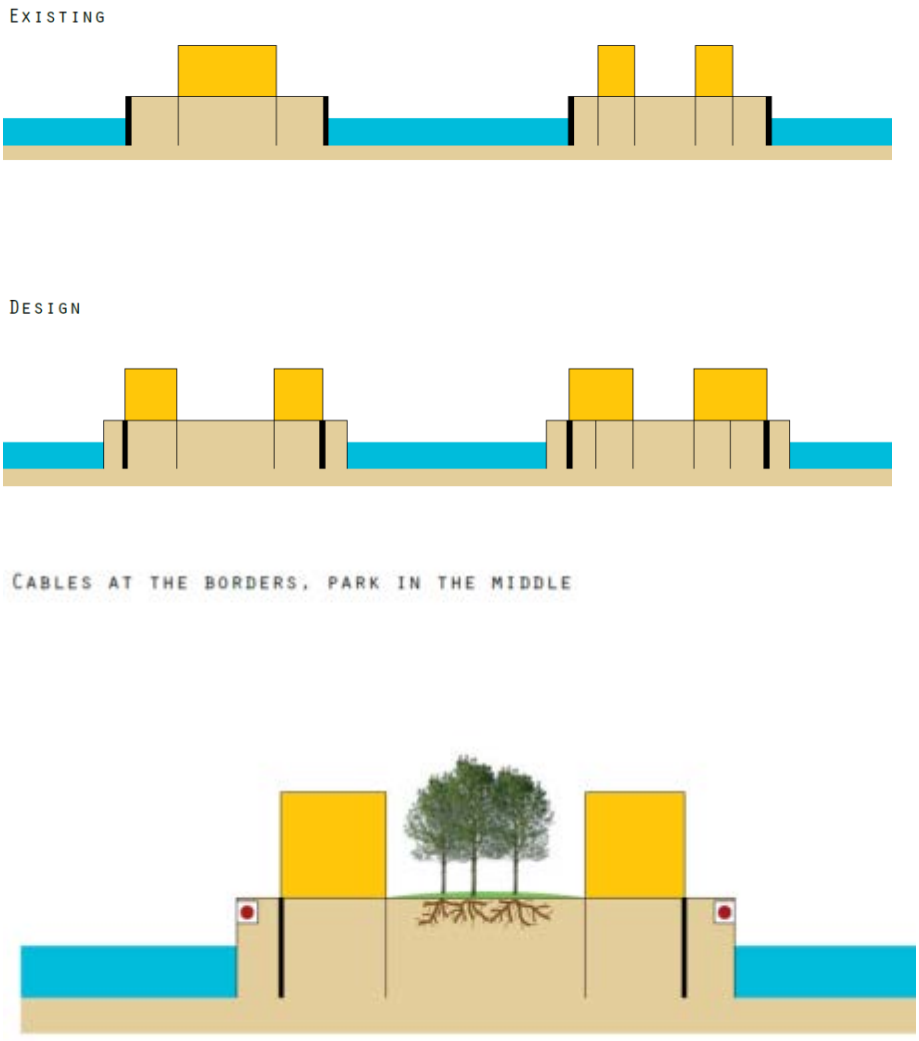


Figure 2-11. Investigate other ways of making fundaments, reuse quays, or old fundaments.

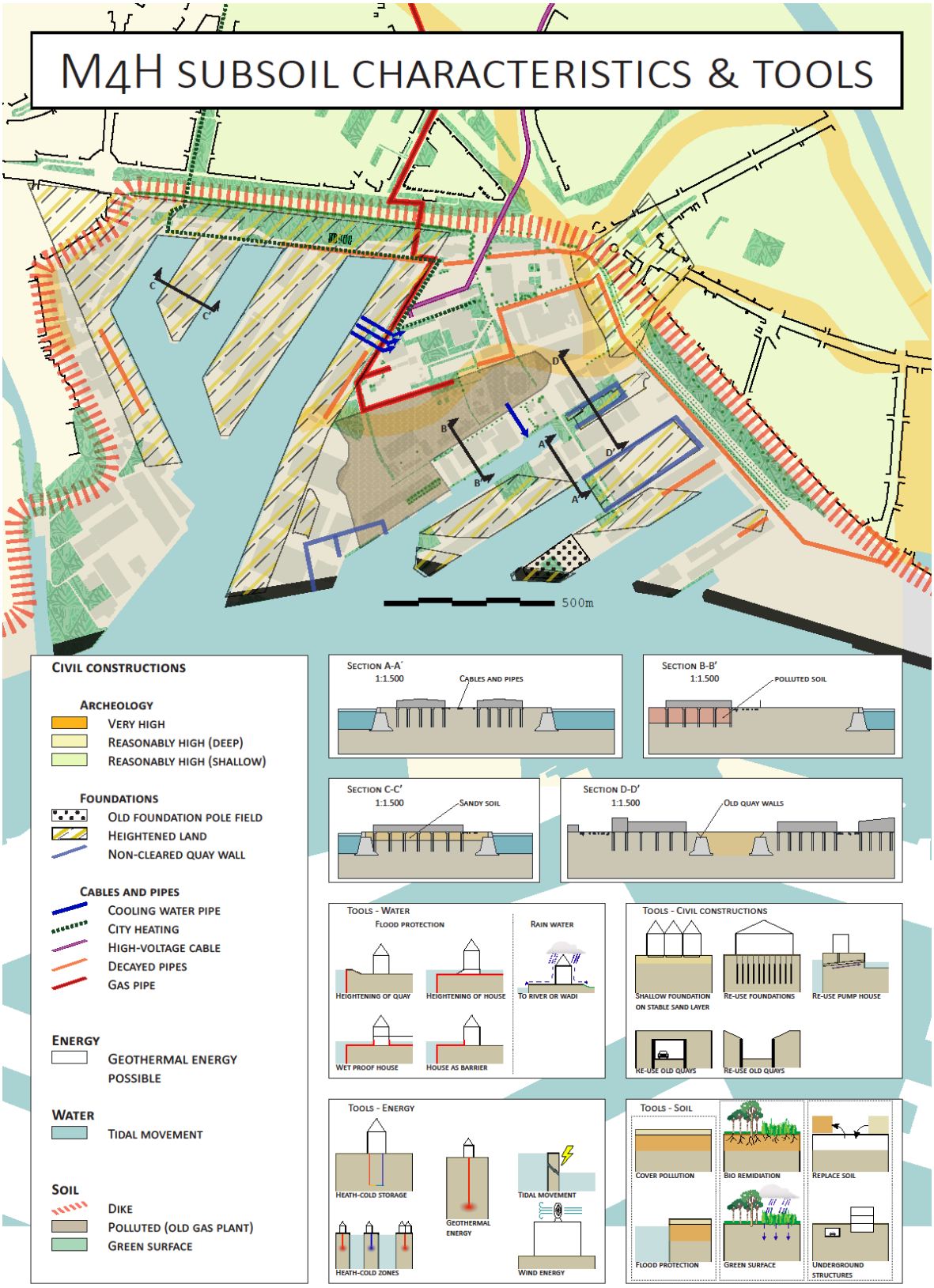


Figure 2-12. Use the subsurface as a spatial framework for redevelopments translated into a subsurface potential map with which can be designed (Mooij, 2014).

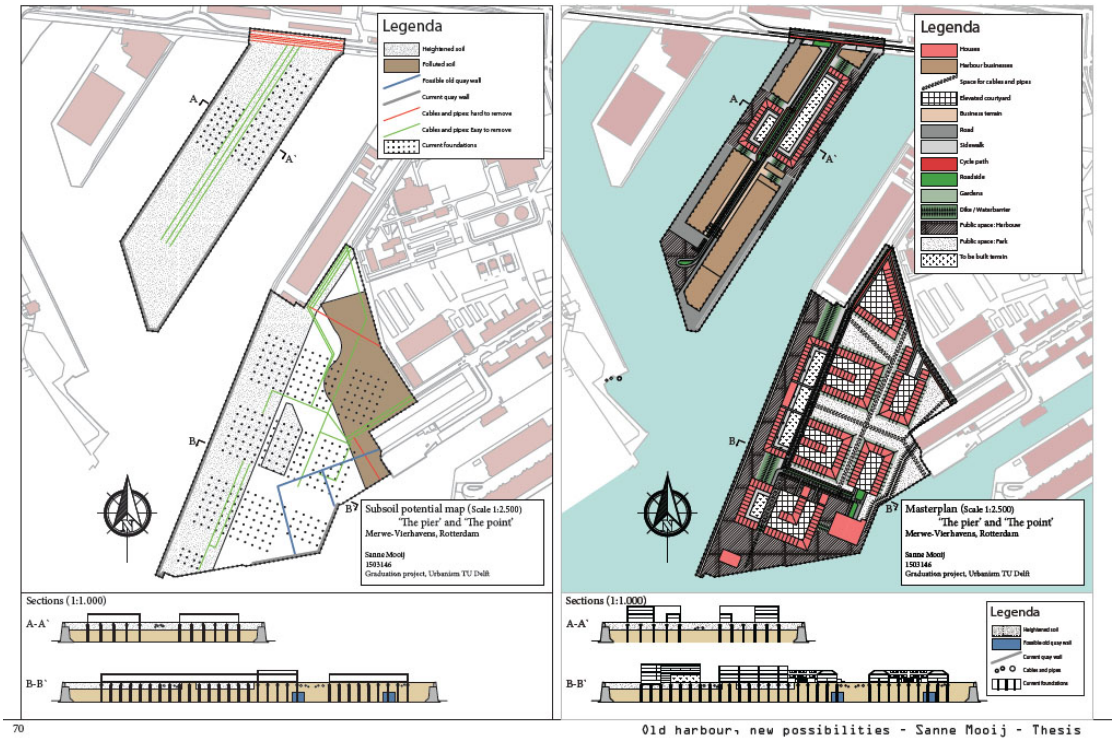


Figure 2-13. Potential map on a lower scale and transferred into the zoning plan. (Mooij, 2014).

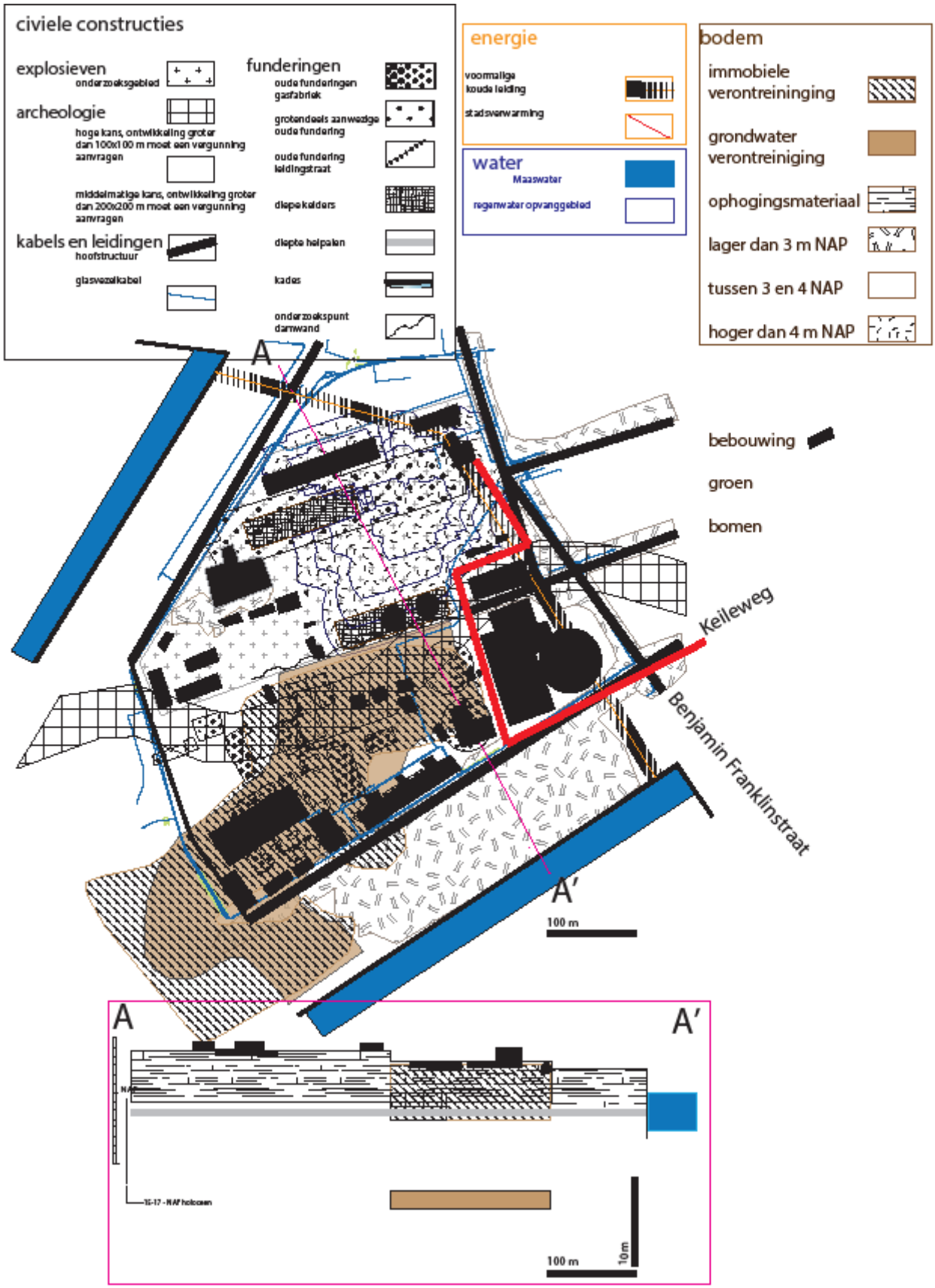


Figure 2-14. Subsurface Potential Map E.ON, Ferro and Eneco location.

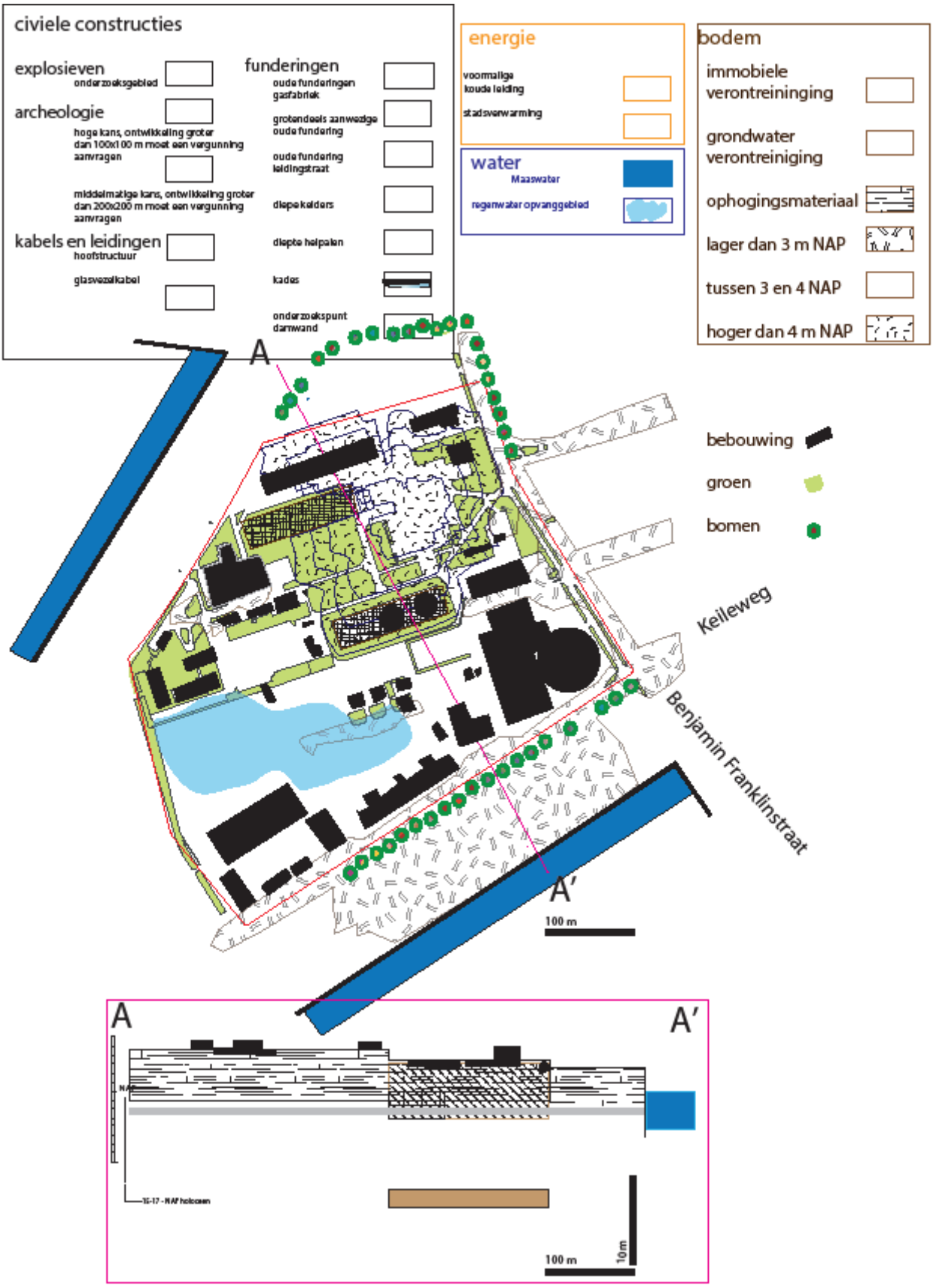


Figure 2-15. Blue green ecology map of E.ON, Ferro and Eneco location.

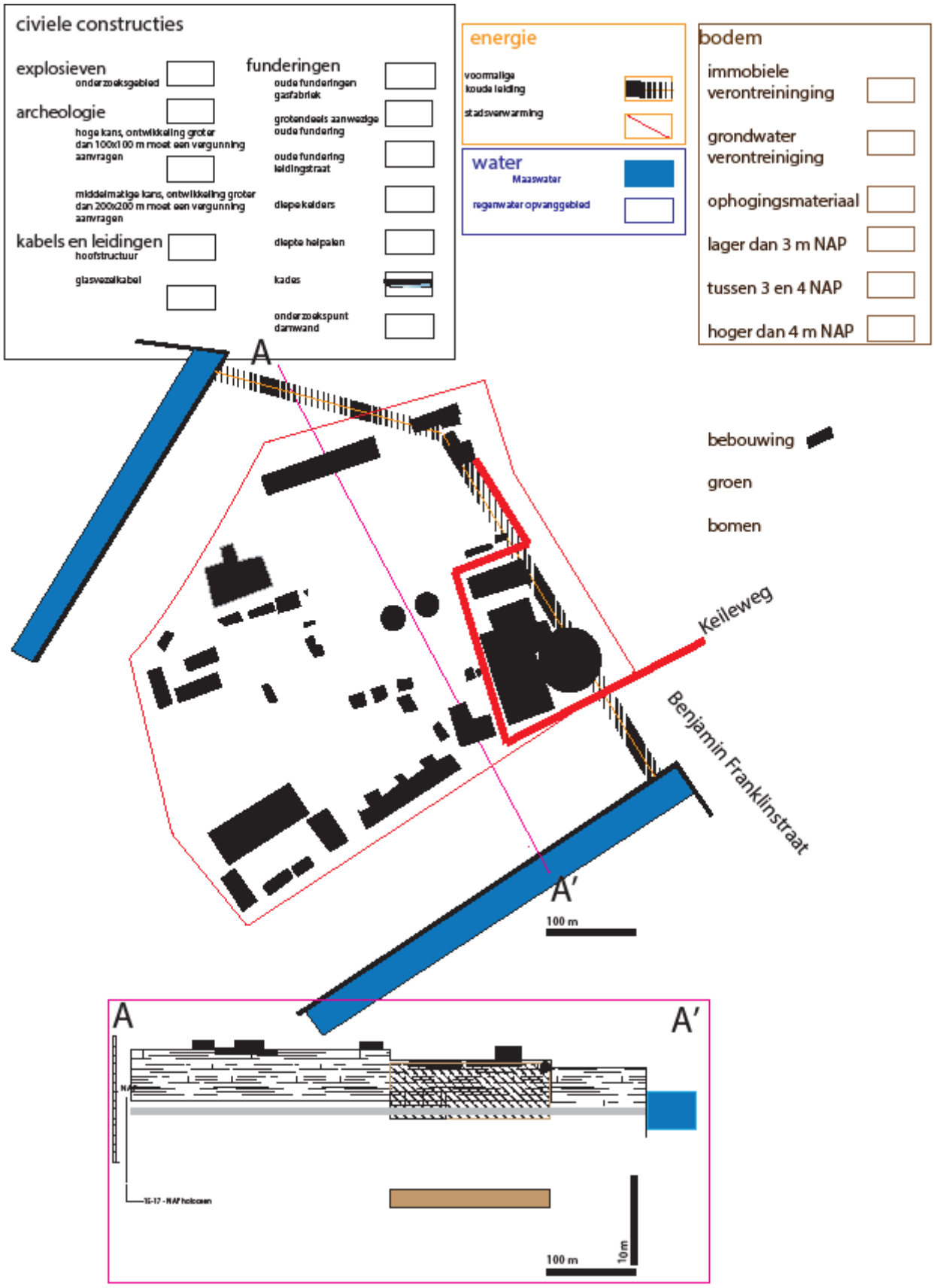


Figure 2-16. Heat and cold map E.ON, Ferro and Eneco location.

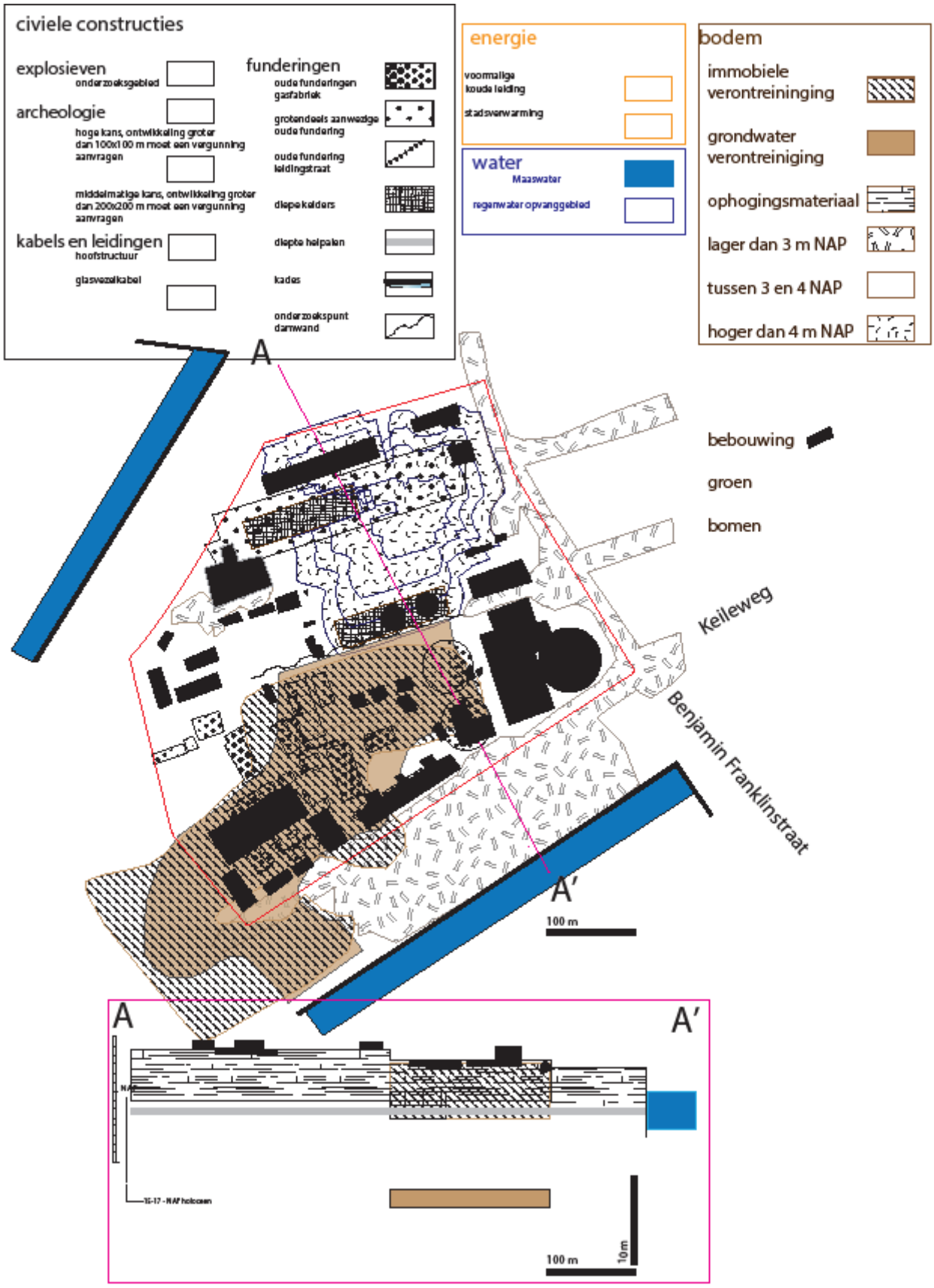


Figure 2-17. Foundations and pollution map of E.ON, Ferro and Eneco location.

2.6 Discussion and advice for the Merwevierhavens case

Taking the subsurface into account offers chances to the area, especially because redevelopment can take a long time, and the subsurface system and the landscape can act as a framework for an organic redevelopment. Underneath, the discussion points and recommendations for the case are presented.

Becoming aware of the subsurface
Designing with the subsurface is something that can only be achieved by a change of the culture within the profession of urban design and urban development. The focus of urban development is based on the socio-economical and spatial components of the city but should be broadened (again) towards the city as a technical construction within a natural system. Starting with the right questions (in this case: how can we take the subsurface into account in the development strategy) helps to get results and contributes to awareness by the developers. The subsurface is an important aspect in developments, also when looking at costs and benefits. In the tenders of the municipality there is a chance to start asking the right questions and giving the right information on subsurface, including groundwater. Not just the environmental aspects (soil and groundwater contamination) should play a role here, but also subsurface chances (ATES, smart construction and spatial planning of cables and pipes), give benefits in the design, but also how areas should be given back after a concession. The tender documents give the opportunity to describe the scope of an area in a 4D matter: with 3D space (including subsurface) and time.

Data and information availability private areas / public space
There is a gap between the information on the subsurface in private areas and public space. Rotterdam gathers data since the 70's about information on the subsurface, but on the private areas, not much is known. Getting the data from the private parties or archives is a very time-consuming job. When transferring the areas, this information should also be handed over, but at the moment, this is not arranged. An exception is for soil quality, for which a status measurement is done. This status measurement can be expanded to other subsurface aspects including as a minimum the aspects that the municipality is responsible for when delivering the sites ready for building to the developer (contamination, cables and pipes, subsurface structures). Within the tender documents it is possible to ask for that at the end of the concession period, the available subsurface information should be transferred to the municipality and the status measurement should be performed before transferring the site back. Also a status measurement should be performed when handing the sites over to private parties. This asks for a good information availability within the municipality.

Take subsurface information into account in the redevelopment
Within the redevelopment, it is advisable to indicate what aspects are of importance within the subsurface: all aspects are not of importance for all developments. The SEES matrix can help indicating which aspects are of importance for the intended land use function (potentially, or specifically for the respective location, Figure 2-18). The derived information, such as costs for a specific development (think about varying remediation costs for land use function industry, or residential area), is very valuable for a developer and a tool such as "gebiedsontwikkelaar" can support this information. When giving information, it is important to offer the available information, but also to indicate which information is of importance, but not available. A map with grey areas does not necessarily mean that the subsurface is "empty".

Finally: it is important to indicate who is responsible for which subsurface aspects. When delivering a site ready for building, aspects as contamination, cables and pipes and subsurface structures are on the count of the municipality, but aspects as carrying capacity and water storage capacity are very important aspects and possibly assets for the developer. Awareness of what is the status and the opportunities is again the key to incorporate the subsurface into the spatial planning in a better way.

As stated, there is a chance to initiate active knowledge exchange within the tender procedure for the development of sites, by the municipality. The whole tender process should be supported by organized knowledge exchange between different sectors. The municipal subsurface engineers should be part of the information and dialogue that is exchanged with the consortia that are subscribing to the tender. The municipality, as a good commissioner, can initiate knowledge exchange between aboveground and subsurface and give data and information about the subsurface in a structured way, in a manner that the market parties can benefit from when taking up the development challenges.

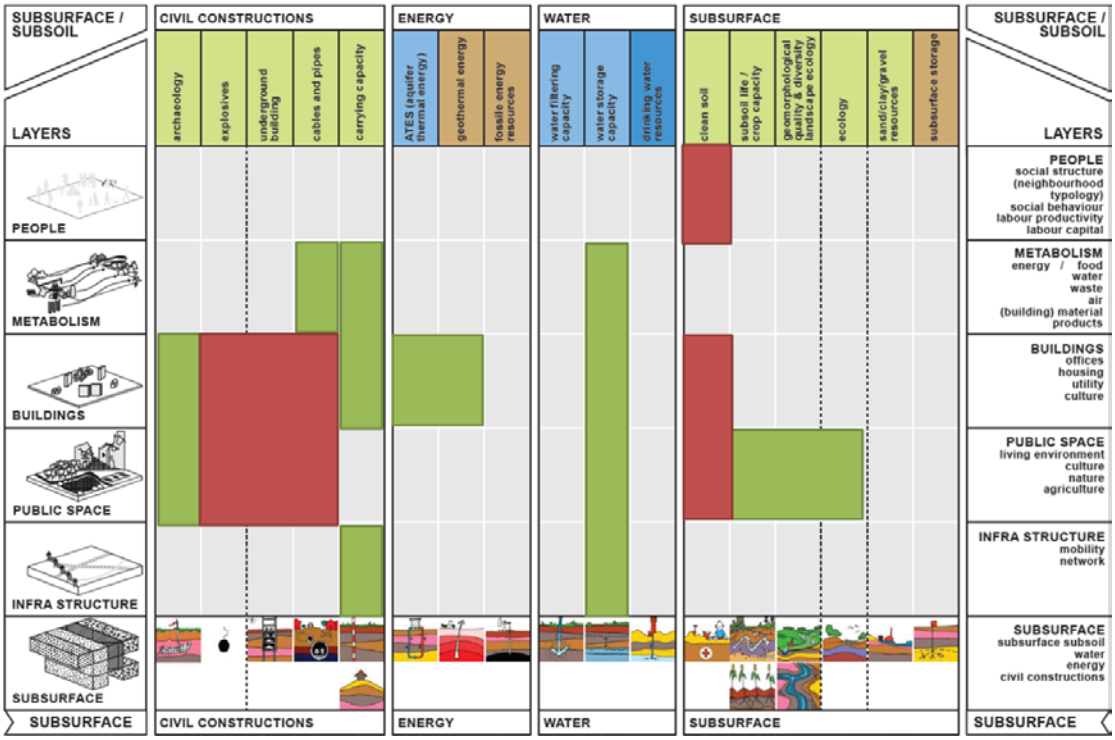


Figure 2-18. Example of a generic subsurface checklist for developments. Red blocks are mainly the responsibility of the municipality when delivering sites ready to build. Green blocks can be taken into account by the developer.

Innovative, nature based solutions

In many redevelopment projects, innovation and sustainability are mentioned as important values. The creative industry is commonly welcomed in order to "brand" the area and act as a starting point for redevelopment: first to attract other businesses, and secondly to make the area attractive also as residential area. In Merwevierhavens, contamination, climate change, soil subsidence and groundwater are also aspects that

need to be tackled. These challenges offer a chance to use the available innovation and knowledge to tackle problems in a sustainable and cost efficient way. Due to that the financial crisis has slowed down the redevelopment, there is in fact time available to search for more innovative and nature based solutions, which in some cases might take more time than regular solutions. Examples of innovative and nature based solutions are green remediation, green-blue structures, functional green, unsealed area to remediate the area and make it more climate proof. The area can potentially act as a pilot area for nature based solutions, to improve spatial quality and brand the area as innovative and sustainable.

Feedback from municipality

The municipality of Rotterdam has provided the following feedback on the case study work carried out within the scope of the Balance 4P project:

- The focus of Balance 4P is relevant, i.e. enhancing the subsurface in the early phases of urban brownfield redevelopment!
- The focus on subsurface showed new opportunities for stakeholders;
- For the first time, the subsurface information from the municipality is widespread and has been used in combination with redevelopment of areas in Rotterdam. This can offer better plans – the student works showed examples of this;
- Complex systems, all aspects cannot be covered in one type of analysis;
- Direct communication is more efficient than documents, but expert knowledge must be delivered in the right form at the right moment;
- It's important to have all information available from the municipality and private companies.

3 Alvat site, Buggenhout, Belgium

The Alvat case study site in the Buggenhout municipality in Belgium, is a former industrial area. Here, public interventions are needed for remediation of the heavily contaminated soil and the site redevelopment. It is today an abandoned and underused site situated along the River Scheldt - a so called “black field”. The Alvat site is in the plan phase, however no clear vision on future land use has yet been developed, because of the presence of the serious soil contamination and an uncertainty about ownership and responsibilities (the site owner has got bankrupt). There has however, been carried out extensive investigations and partial remediation of the contaminated soil by OVAM[8].

The activities carried out within the case study work were:

- stakeholder analysis (quick-scan);
- a student project where the SEES methodology was applied;
- generation of redevelopment alternatives based on SEES and stakeholder consultations;
- a risk assessment, and;
- various sustainability assessments of the alternatives.

All activities for the Alvat case study site within the Balance 4P project were carried out during the period December 2013 – December 2014.

3.1 Site description

The Alvat site is located between Antwerp and Brussels. The site is now an abandoned and underused industrial area of 4.6 hectares, located in the municipality of Buggenhout along the river Scheldt and adjacent to a living area in the North (Figure 3-1). In the Southeast there is the old railway Dendermonde-Antwerp that only serves as a touristic attraction and just across of this railway another residential area. On the East side agricultural activities take place and on the Southwest industrial activities.

Figure 3-1. The Alvat site in Buggenhout.

[8] OVAM - Openbare Vlaamse Afvalstoffenmaatschappij. The Public Waste Agency of Flanders is a regional authority responsible for sustainable management of waste and materials and prevention of soil pollution and carrying out of soil remediation. http://www.ovam.be/

Until 1995 ALVAT N.V. owned the site. Due to the former activities of the company (container reconditioning services and the production of new containers) the site was highly polluted. Activities such as storage of oil products and solvents in tanks and containers, cleaning of containers using these solvents and storage of containers across large parts of the site gave rise to contamination with BTEX, VOCs, mineral oil, heavy metals, PCB and PAHs (Figure 3-2). In addition, in February 2008 an industrial landfill was found nearby the railway that consisted of containers (filled with thinners), plastic waste, wood, concrete, paint residue, etc. At this landfill, heavy metals, volatile organic hydrocarbons, phenols and cresols, phthalates, halogenated hydrocarbons, mineral oil and methylisobuthylketon were measured.

Figure 3-2. Aerial view of 1987 indicating potentially suspicious zones (A: processing liquid waste; B: processing (liquid) waste and burn-out of containers, C: processing liquid waste (above-ground and underground tanks), D: processing empty containers and burn-out of containers and E: Landfill.

Since the bankruptcy of Alvat N.V. in 1995 the site is under the supervision of a curator. The Alvat site is seen as a blackfield, a location where a market-based redevelopment is not possible due to the heavy pollution. When a site is seen as a blackfield, OVAM can acquire the site and finance the remediation so the site can be reused/redeveloped. OVAM already financed a part of the remediation (remediation of the landfill) at the Alvat site and during the work with the case, a brownfield developer specialized in the purchase and remediation of contaminated grounds took interest in the site.

The municipal structure plan (gemeentelijk ruimtelijk structuurplan) was approved in 2005 and indicates that the Alvat site could be developed as a park and recreational area along the river Scheldt and a limited residential function. However, this is not easily executable as it is in contradiction with other plans such as the zoning map (gewestplan), where the site is designated as industrial area. There was no spatial

implementation plan (Ruimtelijk Uitvoeringsplan) yet, but consultation with the Flemish Region (Vlaams Gewest) was ongoing concerning the reuse.

The redevelopment of the Alvat site was blocked. The major bottlenecks beside the presence of a serious soil contamination were the uncertainty about the future destination and the ownership situation. On the existing zoning map (gewestplan) the site is coloured as an industrial area.

3.2 Stakeholder analysis

A problem that prevented redevelopment of the site in the past, has been the different interests of the stakeholders. The site is situated between small residential areas and at the border of an industrial area under redevelopment. The province of East Flanders, together with the city of Dendermonde, the POM East Flanders (Development agency of the province of East-Flanders) and Waterwegen en Zeekanaal have been working on the redevelopment of the industrial site "Oude Briel" adjacent to the Alvat site. This site will become a water bound business park, given its location on the waterfront, the depth of the river Scheldt (ships of 2.25 tons, upstream only 1.3 tons) and the presence of 2 quays (loskades). The Alvat site could potentially also be a part of this project. Due to its location the main ongoing discussion has been related to its future destination (industry vs. residential area). This choice has important consequences for the profitability for private redevelopers to redevelop the site.

The Crosby method (Crosby, 1992) is applied to perform a stakeholder analysis for the Alvat area in Buggenhout. The initial ample list of stakeholders was completed with the help of the representative from OVAM, see Table 3-1. For the Alvat case, the four stakeholders in bold were consulted in individual interviews.

Table 3-1. List of stakeholders and their interest in the Alvat area (stakeholders in bold are consulted individually).

GROUP	GROUP'S INTEREST IN ISSUE	RESOURCE
Municipality of Buggenhout	A good urban development which abide to the local political objectives	Leverage
Province of East-Flanders	Incorporation of the Alvat site into a water-bound Business Park	Leverage
Waterwegen en Zeekanaal		Leverage
City of Dendermonde		Leverage
Development agency of the province of East-Flanders		Leverage
Agentschap ondernemen	Bronwfieldconvenant, support in finding possibilities for subsidies	Leverage

Table 3-1. Continued.

GROUP	GROUP'S INTEREST IN ISSUE	RESOURCE
Santerra	Brownfield developer	Specialized in the purchase and remediation of contaminated grounds – Investment
OVAM	Responsible authority for soil contamination and remediation	Expertise Decision maker Regulator
Land owner = curator (company-bankrupt)	Selling the site	Leverage
Inhabitants	Minimal hindrance during the redevelopment and from the reuse (potential traffic issues). Potential users (in case of parks, recreational area, commercial area, …)	Leverage

From the discussion with Waterwegen en Zeekanaal (the Waterway Administration) it could be concluded that the administration has the potential right of first use and can enforce the different parties to use it as a waterbound industrial area. This scenario is also still preferred by this administration. However, to get something realized, support from the municipality and local citizens is important. Also, the definition of "waterbound industry" does not necessarily mean construction of heavy industry (e.g. concrete factory). However, there needs to be a potential for waterbound transportation of goods on the longer run. There is also a willingness to include elements to reduce the burden for neighbouring households and increase the profitability for private redevelopers (mixed use with some residential areas or light industry as buffers).

The municipality has a preference to let the site be used as residential area or a mix recreational/residential area. An important objective is to maintain the existing living conditions for households surrounding the site. Hindrance from additional traffic due to activities on the site (trucks, additional cars) should be kept to a minimum. Also, noise hindrance from industrial activities on the site is a concern. Creating a good view on how transportation issues will be solved in the different scenarios is important. However, local employment can be an important motivator to also have support for more industrial redevelopment. Companies with a local historical tradition are for example more interesting for the municipality. The fact that there is willingness from the municipality towards more industrial activities was confirmed in a meeting between the municipality and OVAM (26/11/2014), where the municipality agreed upon including a waterbound activity, on the condition that attention was paid on the mobility.

The private redeveloper has been potentially interested in buying the site. It is however unclear which destination the site can have. A potential direction suggested by the redeveloper goes towards light industry (KMO), with a potential to create waterbound transportation of goods. How to solve the soil and groundwater pollution does not seem complicated from a technical point of view, but potential alternative remediation options are limited for this site.

After the interviews it was clear that there was no clear solution on the land use that satisfies all stakeholders. Because it was not possible to define one outcome, several alternatives visions (urban plans) were designed and compared.

3.3 Generation of redevelopment alternative(s)

From the results of the stakeholder interviews and discussions with soil experts from VITO, Lena Niel, a Master student from TU Delft, applied the SEES method (see Box 2.1) and designed potential redevelopment strategies (Niel, 2014).

3.3.1 Exploring the system (SEES)

The Alvat case is an abandoned site due to the contamination and the different interests of the stakeholders. Therefore, the research question was 'How to develop an urban plan for the Alvat site in the near future by combining the technical characteristics of the contaminated subsurface with spatial qualities of an urban plan?'.

Although it is not common that both technical engineers and urban designers work together from the beginning of the whole process, this project is trying to do so. This means that both engineers, who are investigating the subsurface from a technical perspective, and (urban) designers, who develop the surface from the perspective of people, are combined. To achieve this goal in practice, the SEES (System Exploration Environment and Subsurface) methodology (see Box 2.1) was used in this case which takes its starting point on this dialogue between technique and spatial design (Hooimeijer, 2013).

Based on the results of the SEES methodology (Table 3-2), it could be concluded that for most topics little opportunities are possible for this site. The redevelopment is mainly dominated by the type and the degree of the soil and groundwater pollution. The uncertainty regarding the current extent of the pollution and the future land use, implies that the plan/urban design should be flexible. Additionally, a generic urban analysis is done. The main conclusions of the analysis are:

- The site is surrounded by housing areas and by a little bit of agriculture;
- Industrial area is situated along the Schelde, not far from the site;
- Daily facilities like grocery stores are reachable within 7 min by car;
- The other side of the Schelde is part of both Natura 2000 and the Sigmaplan, why new ecological floodplains will be created in the near future;
- A bicycle path goes around the site. Nowadays it has to make a strange turn due to the layout of the former plant.

Table 3-2. Results of the SEES method at the Alvat site.

CIVIL CONSTRUCTIONS	
Archaeology	not relevant
Explosives	not relevant
Underground building	not relevant; buildings are broken down
Cables and pipes	not relevant
Carrying capacity	not relevant
ENERGY	
ATES (aquifer thermal energy storage)	not relevant
Geothermal energy	not relevant
Fossil energy resources	not relevant
WATER	
Water filtering capacity	not relevant (% paved surface, etc.)
Water storage capacity	not relevant
Drinking water resources	not within a distance of 2 km
SUBSURFACE	
Clean soil	contaminated; remediation necessary
Subsoil life/crop capacity	no agriculture or protected natural areas
Geomorphological quality & diversity landscape ecology	not relevant
Ecology	not relevant
Sand, clay, gravel resources	not relevant
Subsurface storage	not relevant

3.3.2 Redevelopment strategies

The main elements in the spatial design following the technical measurements in the subsurface are (Figure 3-3 and Figure 3-4):

- Main road connections and pumps (located between the parking garages to lead the groundwater flows as much as possible in the direction of the treatment station in one of the garages);
- (Temporary) ecological park (situated in the zone where accurate information on the contamination is lacking). The ecological park uses natural attenuation as a gentle remediation technique. Depending on the evolution of the pollution, this park can be replaced by built-up areas or kept more permanently;
- Phasing to develop a dynamic urban plan.

Figure 3-3. Spatial measures as a starting point of designing alternative redevelopment strategies. From Niel (2014).

Figure 3-4. Land use scenarios "Small and medium enterprises-light industry" versus "residential". From Niel (2014).

The urban designs were transferred into land use maps as is required for the impact assessment. The impact assessments also requires further assumptions on the land uses surrounding the buildings. For demonstration purposes the "light industry" alternative mainly contains hardened surface around the buildings and the "household" alternative

mainly contains green surface. Based on stakeholder feedback, a “heavy industry” alternative and a “mixed use” alternative combining light industry and residential area were added (Figure 3-5).

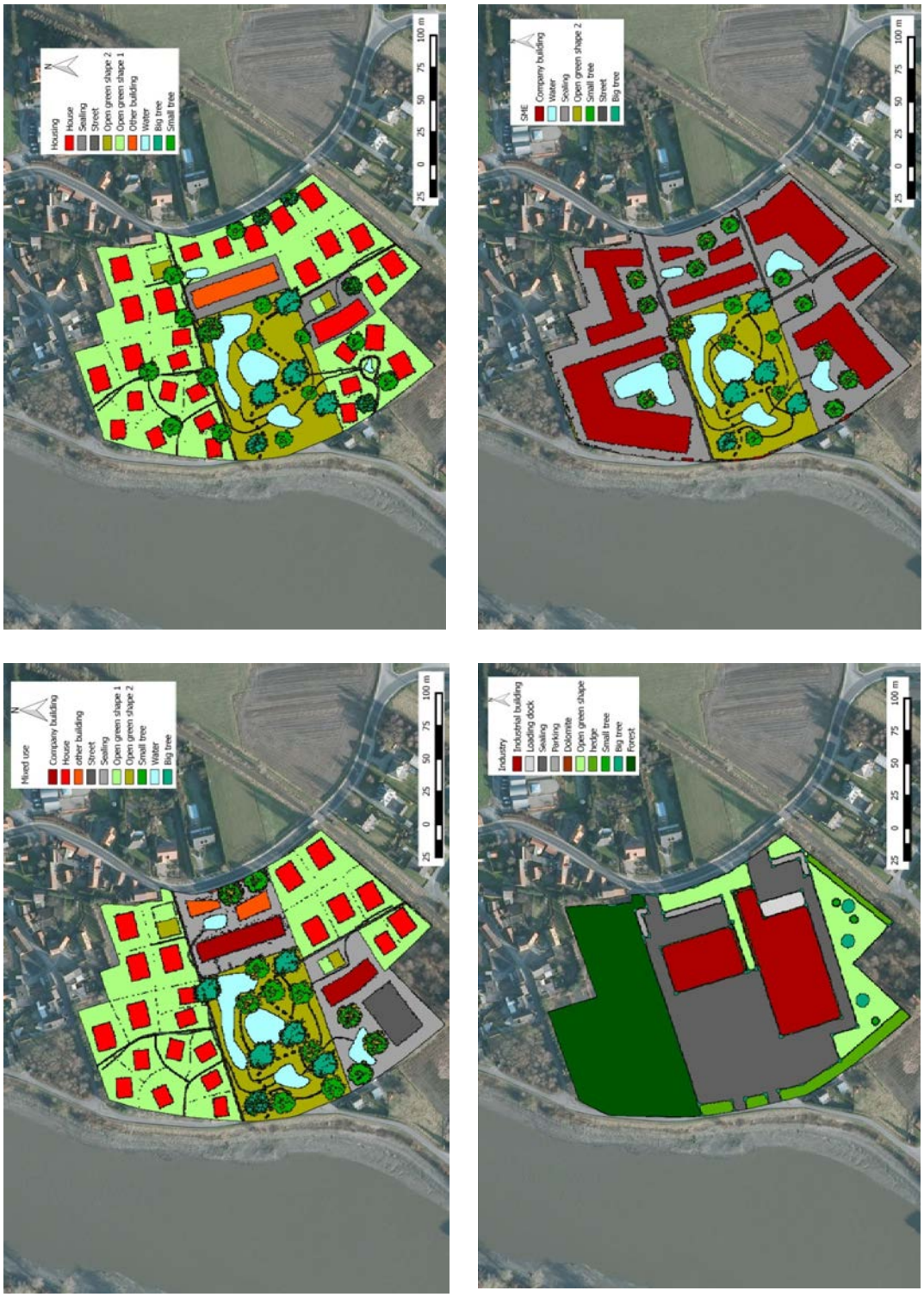


Figure 3-5. Land use maps for 4 different redevelopment scenarios.

3.4 Assessments of project redevelopment alternatives

Several instruments were applied to assess the redevelopment alternatives from different perspectives. The following sections presents the different assessments carried out.

3.4.1 Risk assessment

Description of the contamination
The curator was unable or refused to take any further steps to remediate the Alvat site, so OVAM conducted an ex-officio descriptive soil investigation and an ex-officio soil remediation project.

In the descriptive soil investigation (2002), two source zones with VOCs (chlorinated solvents and BTEX) and mineral oils were identified in soil and groundwater (see zone A and Landfill in Figure 3-6 and Figure 3-7). Heavy metals, PAHs and PCBs were also found in the unsaturated zone. The soil is contaminated up to 7.5 m. The groundwater plume moved downward into underlying aquifers (VOCs are found at the clay layer on 15 meter below ground level) and has spread to a limited extent to the surrounding (Figure 3-7). On the side of the railway an industrial landfill was found that consists of vessels, plastic waste, wood, concrete and stone material.

While the contamination with heavy metals and VOC's in groundwater was spread over a large area of the site, the contamination with mineral oil and BTEX was mainly situated nearby the landfill. The volume of the groundwater contaminated with BTEX and VOC's nearby the landfill was estimated at 14500 m^3 and at zone A (near the Scheldt) on 7850 m^3. In addition to these two large groundwater contaminations, there were also four smaller present (at PP13, at PP14/PP4, at PP2 and at PP3).

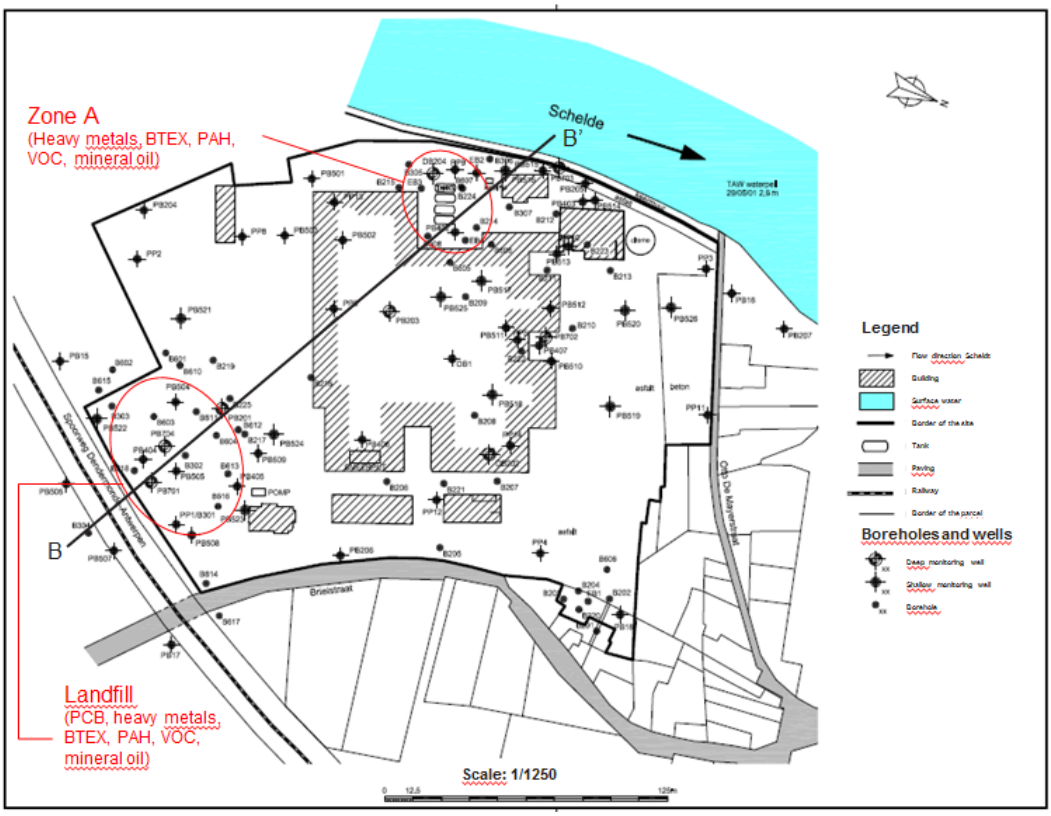


Figure 3-6. Soil contamination (top view; based on information from ABBO Ecorem; 2002).

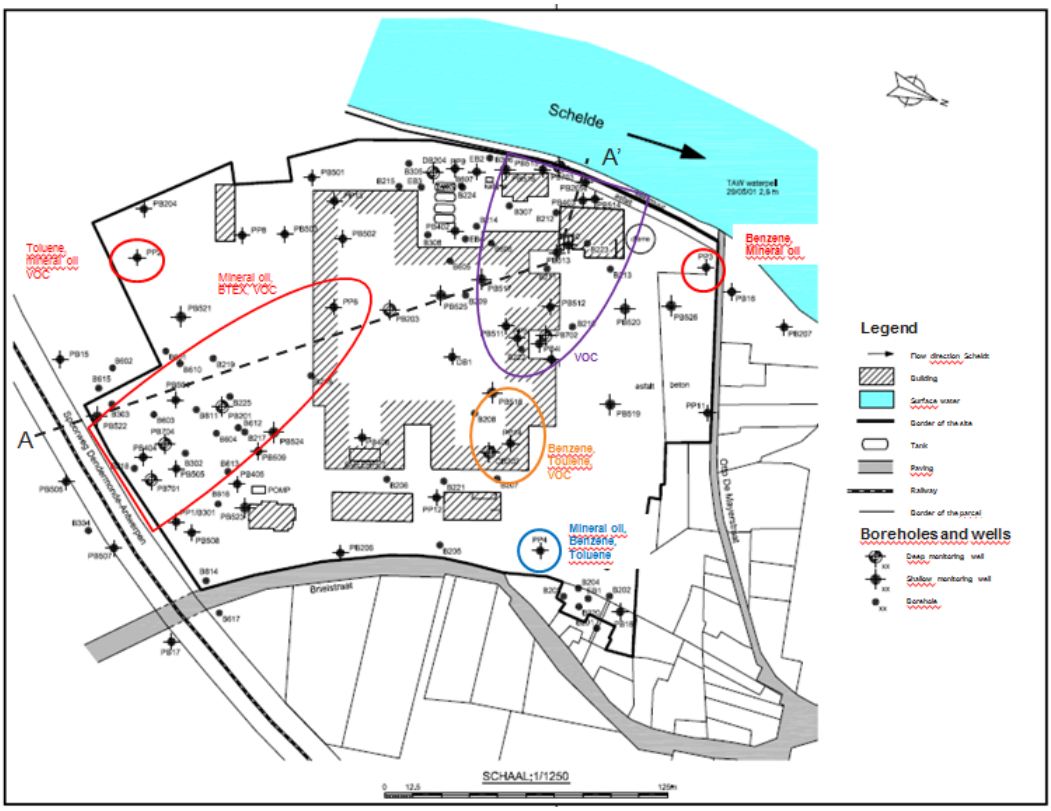


Figure 3-7. Groundwater contamination (top view; based on information from ABBO Ecorem; 2002).

The landfill near the railway and zone A near the Scheldt were indicated as two source zones. The landfill was already remediated up to 3 meters depth (see next paragraph 'remediation') but the second contaminated zone located between the former above-ground storage tanks and the Scheldt (Zone A) was not yet cleaned up. The volume of contaminated soil with heavy metals, BTEX, PAH, VOC and mineral oil was estimated at 4100 m³ (see Table 3-3). The maximum concentrations in the unsaturated soil at zone A (measured during the descriptive soil investigation 2002) are summarized in Table 3-4.

Table 3-3. Contamination at zone A (near the Scheldt).

PARAMETER	AREA (m²)	DEPTH (m)	VOLUME (m³)
Heavy metals	370	3	1110
BTEX	610	3,5	2135
PAH	470	2	940
VOC	585	4,5	2633
MO	**820**	**5**	**4100**

Table 3-4. Maximum concentration at zone A (near the Scheldt).

PARAMETER	CONCENTRATION (mg/kg DS)
Lead	48000
Cadmium	73
Chrome	6600
Copper	4600
Zinc	18000
Toluene	28000
Ethylbenzene	5500
Xylene	18000
Benzo(a)pyrene	47
Trichloroethene	2300
Tetrachloroethene	840

The modelling results of the risk assessment carried out during the descriptive soil investigation with the human exposure model VLIER HUMAAN (ABBO Ecorem N.V., 2002) indicated that there is a human exposure risk based on the pollution in the unsaturated soil at Zone A and this for the future destinations industrial and residential use. So excavation of the contaminated soil at zone A (4100 m³) is necessary.

Because of the groundwater flow in the direction of the Scheldt the identified source zones (landfill and zone A) and the associated plumes form a threat for the surface water of the river Scheldt. There is a receptor at risk so remediation of the source zones and the groundwater contamination is necessary. Next to the risk of spreading there is also a human risk as a result of volatilization.

3.4.1.1 Remediation strategies

A partial soil remediation project was approved in April 2007 for the remediation of the landfill. OVAM hoped that this partial clean-up would result in an increase of the profitability in the redevelopment of the site and in attracting private investors (brownfield developer) for the further remediation and redevelopment of the site.

Given the complexity of the remediation and the size of the landfill, the remediation was carried out in different phases. During the first phase (2010) the landfill next to the railway was removed. Figure 3-6 shows the excavated zone. Around 13500 tons of material was transported to a ground remediation centre with the exception of the PCB contaminated soil (dumping). In a second phase (2011), the remaining contaminated soil on the side of the railway was excavated. For stability reasons landfill material remained in the narrow strip between the sheet pile and the railway.

The next steps towards a full remediation of the site are currently not known in detail. Before an integrated soil remediation project for the entire site can be drawn up, an actualization of the pollution degree and the extent of the contamination is necessary since the latest results date back to 2002. This includes an update of the groundwater concentrations and an update of the source zones. It is also important to investigate if natural attenuation occurs (accumulation of cis-DCE in deeper groundwater and the formation of VC in the phreatic groundwater layer).

A rough estimation of the remaining costs of the remediation was performed for OVAM by a soil expert in 2012. The total cost was estimated on 1.550.000 euro. The soil remediation suggested by the soil expert consists of an excavation with drainage for the unsaturated source zones. The groundwater remediation will be performed using a multi-phase extraction system. The deep groundwater contamination is governed by deep wells or a barrier.

Since a human risk is associated with the soil contamination at the source zones (for example zone A) remediation of this zone is needed (Figure 3-6). For the remediation of such zones, only excavation in combination with drainage and transportation of the contaminated soil to a ground remediation centre is suitable.

Site specific risk assessment to define risk-based remediation targets for groundwater

Targets based on human risk assessment (S-RISK[9])

The risk-based approach to the assessment and management of the contaminated site is based on S-RISK, a tool to evaluate exposure and human health risks from soil contaminants under a variety of land uses and contamination profiles. The tool calculates clean-up values based on site-specific risks and remediation objectives.

[9] S-Risk is a model for assessing exposure and human health risks at contaminated sites. Fate and distribution of chemical pollutants in soil are calculated according to steady-state conservation of mass principles. S-Risk is made available in a web application (https://www.s-risk.be). The tool is initially designed to meet the requirements of the Flemish regulatory context with regard to contaminated sites. Due to its flexibility and open structure, applications outside this regulatory context are possible.

Different land use scenarios can lead to a difference in the exposure pathways and the associated risks. The model calculates concentrations in ambient and indoor air due to volatilization and soil resuspension, in drinking water from leaching or permeation, in food due to plant and animal uptake. Exposures are predicted for the inhalation route (ambient, indoor, bathroom air), oral (water, food, soil, dust) and the dermal (water, soil, dust) route. Calculations are performed for a predefined set of age intervals, ranging from children to adults. Risks are calculated by comparing exposures with toxicological reference values and concentrations with toxicological or legal reference concentrations.

Based on S-RISK, the risk-based remediation targets for groundwater for several land uses are summarized in Table 3-5 (µg/l). The selected land uses are residential with garden (RwG), residential with garden without basement (RwG,noB), industry (offices) and park (outdoor recreation). When concentrations above the maximum solubility are calculated values of the maximum solubility are displayed in blue bold in the Table 3-5.

Table 3-5. Risk-based remediation targets for groundwater for BTEX (µg/l) and some VOC (µg/l).

PARAMETER	**B**	**T**	**E**	**X**
Standard[0]	10	700	300	500
RwG[1]	47-84	3292	**165000**	10610
RwG,noB[2]	100-177	6846	**165000**	21700
industry[3]	250-1250	11000-38000	**165000**	33200-1E5
park[4]	**1,78E+06**	**5,23E+05**	**1,65E+05**	**1,66E+05**

PARAMETER	**PCE**	**TCE**	**c-DCE**	**VC**
Standard[0]	40	70	50	5
RwG[1]	326,7	1179	762,4	6,6-39,4
RwG,noB[2]	665	2437	1617	16-84
industry[3]	4000	13000	2500-10000	16-440
park[4]	**1,50E+05**	**1,40E+06**	**8,00E+05**	**1,12E+06**

0: Flemish soil remediation target; 1: risk based target for residential areas; 2: risk based target for residential areas (buildings without basement); 3 = risk based target for industrial areas; 4: risk based target for recreational areas

In the monitoring wells at the landfill, concentrations were found above the risk based remediation targets for groundwater for the land uses ‘residential (with garden)’ and ‘light industry’. This means that for both future destinations a remediation is necessary but with different goals/remediation objectives for groundwater.

In the monitoring wells at Zone A (near the Scheldt), concentrations were found above the risk based remediation targets for groundwater for the land use 'residential (with garden)', but not for the land use 'light industry'. This means that only for the future destination 'residential', a remediation of the groundwater is necessary based on the human risk assessment. However, because of the risk of spreading towards the Scheldt, remediation is still necessary.

Because of the benzene concentrations measured in the monitoring wells PP2, PP3 and PP4, there is a human risk for the future land use 'residential'. Only at monitoring well PP4 there is also a human risk for the future land use 'light industry'.

For the future land use 'outdoor recreation' there is no human risk associated with the groundwater contamination.

Risk based target setting
Because of the groundwater flow in the direction of the Scheldt, the Scheldt itself is at risk. The impact of the remediation of the landfill on the groundwater concentrations is not known, nor if natural attenuation occurs. A data update of the pollution degree and the extent of the contamination is necessary since the latest results are from 2002. Based on that information and knowledge of the groundwater velocity, retardation and degradation the risk needs to be verified. This information was lacking at the moment for the case study work and will eventually determine the risk based target.

Based on the risk assessment, it can be concluded that for some pollutants (toluene, ethyl benzene, xylene) the risk of spreading will determine the risk based targets and not the land use and the associated human risks. For other parameters like benzene and vinyl chloride the human risk assessment will determine the risk based targets. When the human risk based remediation target is more stringent than this for spreading, the land use will have a limited impact on the remediation approach. The land use will not affect the choice of the feasible remediation techniques, but it can have an impact on the duration of the remediation. If the site will be used for residential area, the duration of the remediation may be longer than for industrial use.

3.4.2 Economic assessment (potential profit private redeveloper)

The economic value of a parcel depends heavily on the potential destination of the parcel and the building density. For this study, the relevant types of land use are residential and industrial land use. The economic value of different land uses (expressed in €/ha per land use) depends on the net income for a private redeveloper that can potentially be generated on the site. This in turn depends on the gross income from selling or renting buildings, minus all the costs for preparation and development of the site, construction of buildings, administration, etc. The residual method for real estate appraisal simulates this reasoning and assesses in detail all factors that affect gross income and costs (Dugernier et al., 2014; Vos, 1996). The gross income is based on market values for renting or selling real estate, as observed in local real estate markets.

Table 3-6 lists the different factors that affect gross income and costs, and distinguishes between factors that are identical for all scenarios and differ between scenarios. The gross income depends on the size of the surfaces (m² living area or m² commercial or production area), the characteristics of the buildings (type, construction quality, level

of completion and facilities), and the environment, which include functional characteristics (such as proximity of transport network, shops, schools, other firms, recreation) and physical characteristics (amenity of landscapes, nuisances, etc.). Whereas the size and characteristics of buildings depend on the redevelopment scenario, the characteristics of the environment are exogenous and identical for all scenarios. The costs depend more or less on the size of the buildings and their characteristics, and the development costs for the non-built up parts of the parcel. As the purpose of this study was to assess the economic value of the parcel after remediation and redevelopment, we did not include costs for purchasing the parcel. The results of the calculation (net income), see Table 3-7, can be interpreted as the amounts available to cover for expenses and risks for the investor and the costs to acquire the parcel, including taxes, administration and purchase.

Data sources to assess gross income and costs are based on a recent study to estimate the impact of land-use policy on real estate values, and for which we distinguish residential and industrial land uses (Durgenier et al., 2014). For industrial land use, we further distinguish between SME or light industry and heavy industry, as the context in terms of government involvement and real estate markets differ. Comparison of potential profits versus old estimations of the remediation costs before the OVAM intervention and more recent estimations after the OVAM intervention is presented in Figure 3-8.

Table 3-6. Overview of factors affecting the economic value of redevelopment scenarios.

FACTORS	INDICATORS	GROSS INCOME	GROSS COSTS	SCENARIO DEPENDENT
Buildings on site				
Size of surfaces	m² living area, m² work area	x	x	Yes
Quality of buildings	Type of building	x	x	Yes
	Construction quality	x	x	Yes
	Level of completion, facilities	x	x	Yes
Outdoors on site				
Size of surfaces	m² parking, storage, private gardens, public green space	x	x	Yes
Quality of outdoors	Level of completion, facilities	x	x	Yes
Location of the site				
Functional characteristics	Proximity to transport network, work	x		No
	Schools, recreation, other firms	x		No
Physical characteristics	Amenity of landscape, nuissances	x		No

Table 3-6. Continued.

FACTORS	INDICATORS	GROSS INCOME	GROSS COSTS	SCENARIO DEPENDENT
Preparation of site				
Remediation costs	Area treated / level of treatment		x	Yes
Demolition costs	m^3 buildings, m^2 sealed surface		x [1]	Yes
Taxes and Admin. Costs			/ [2]	/ [2]
Purchase of parcel			/ [2]	/ [2]

x [1] : not further included in the study. / [2] : these costs are not accounted for in the residual method for real estate appraisal.

Table 3-7. Result of economic value of the different scenarios.

INDICATOR	UNIT	HOUSING DENSE	HOUSING	SME	INDUSTRY	MIX
Land uses						
m^2 floor area *	m^2	18.361	13.573	12.672	20.892	11.154
Grey infrastructure	m^2	30.345	30.345	12.942	20.831	25.974
Green infrastructure	m^2	3.633	3.633	16.109	13.992	7.875
Gross income						
Rent €/year/m^2	€/m^2	5,9	5,9	3,3	4,5	5,6
Total rent year	k€/year	1.288	952	507	94	663
Current Value future rents (3 - 4 %)	million €	43	32	13	2,4	24
Costs						
Building costs	million €	26	19	8	1	14
Grey infractructure	million €	0,54	0,54	2,42	-	1,18
Green infrastructure	million €	0,91	0,91	0,39	0,62	0,78
Total costs	million €	27	21	10	1,2	16
Net income	million €	**16**	**11**	**2,3**	**1,2**	**7,6**

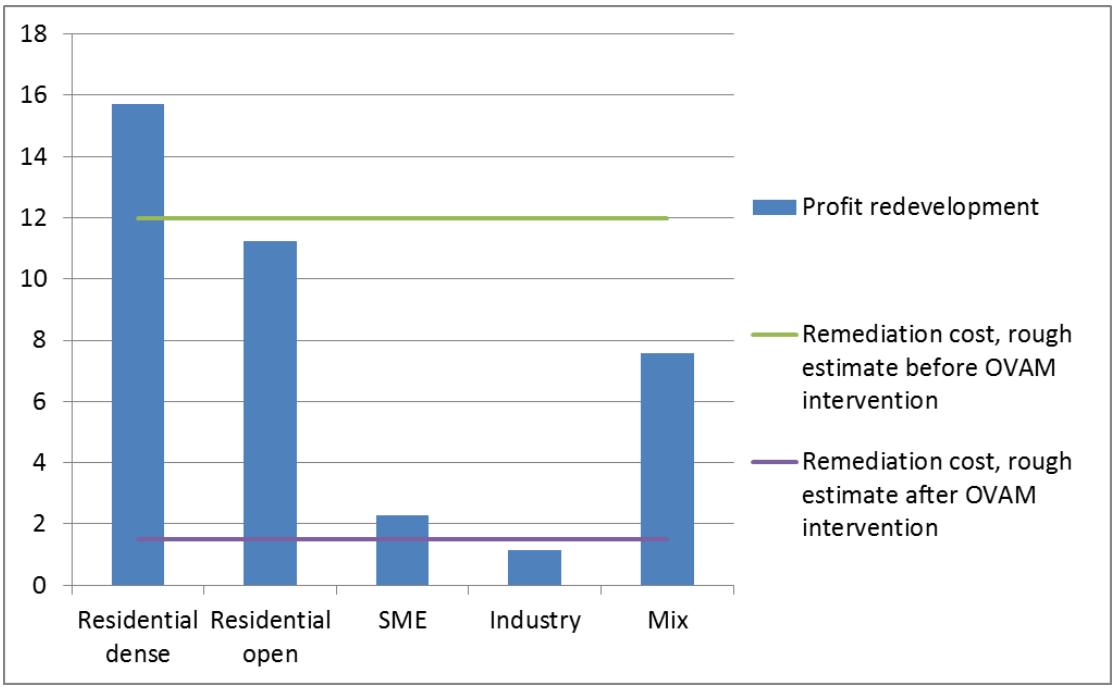


Figure 3-8. Comparison of potential profits versus old estimations of the remediation costs before the OVAM intervention and more recent estimations after the OVAM intervention.

3.4.3 OVAM MCA

The selection of the remediation techniques to achieve the remediation targets was already performed by a soil expert in the past. The most appropriate remediation strategy (combination of technologies) was selected according to the BATNEEC principle (Best Available Technology Not entailing Excessive Economical Costs). The soil remediation suggested by the soil expert consists of an excavation with drainage. The groundwater remediation will be performed using a multi-phase extraction system. The deep groundwater contamination is governed by deep wells or a barrier.

The OVAM multi-criteria analysis (MCA) is typically used to provide insights on the most sustainable remediation strategy (combination of technologies) (OVAM, 2013). For this case, two or three remediation variants can be evaluated with the MCA. The MCA is based upon three main aspect groups (environmental, technical and financial aspects) using several criteria for each group. The environmental aspects are divided into 'local' and 'regional/global' environmental aspects (Figure 3-9). The carbon-calculator is used to evaluate one of the 'regional/global environmental effects'. Scores are given to each criterion and to each variant with a total of 15 points. Most of the scores are qualitative, some are semi-quantitative. For the Alvat case, two variants were compared for the different land uses (Variant 1 - residential and variant 2 - industry).

Criteria	Weighing factor	Variant 1 (residential)	Variant 2 (industry)
Environmental aspects			
Local aspects	33		
Legal remediation objectives soil	6,6	5	5
Legal remediation objectives groundwater	6,6	6	4
Total reduction of contamination load	6,6	6	4
Direct emissions to environmental compartments	6,6	4	6
Duration of remediation & policy objectives	6,6	4	6
		825	**825**
Regional/global aspects	12		
Use of raw materials and recycled materials (carbon calculator)	8	4	6
Production of non-reusable waste during remediation	4	4	6
		96	**144**
Technical and social aspects	22		
Nuisance during remediation	5,5	4	6
Restrictions for land use after remediation	5,5	7	3
Damage caused by remediation works	5,5	5	5
Safety measures during remediation	5,5	5	5
		462	**418**
Financial aspects	33		
Remediation costs	22	4	6
Cost of residual contamination	11	6	4
		330	**330**
	TOTAL	**1713**	**1717**

Figure 3-9. OVAM MCA application for the different land uses.

The main differences between the alternatives is shortly discussed below:

- Legal remediation objectives groundwater

For some parameters like benzene and vinyl chloride the human risk based remediation target will determine the objective for groundwater and so the objectives for groundwater will be different for the variants. The risk based remediation targets for variant 1 (residential) are more stringent than for variant 2 (industry).

- Total reduction of contaminated load

The remediation target for the unsaturated soil is the same for both land uses, but not for groundwater. Because of the more stringent remediation objective for groundwater for residential area, the total reduction will be higher for variant 1.

- Direct emissions to environmental compartments

The purified water will be discharged to the river Scheldt in both variants, but the duration of the remediation for 'residential area' might be longer than for 'industrial use' and therefore the direct emissions will be higher for variant 1.

Score: (4) residential – (6) industry

- Duration of remediation & policy objectives

As already mentioned the duration for the remediation for residential area (variant 1) will be longer to achieve the risk based targets for groundwater.

- Use of raw materials and recycled materials (carbon calculator)

The fact that the duration of the remediation is longer for variant 1 means that the total amount of CO2 emitted will be higher than for variant 2.

- Production of non-reusable waste during remediation

The fact that the duration of the remediation is longer for variant 1 means that the total amount of non-reusable will be higher than for variant 2.

- Nuisance during remediation

The fact that the remediation approach is the same for both land uses (variants) means that the nuisance will be the same except the fact that it will last longer for variant 1 (longer duration of the remediation).

- Restrictions for land use after remediation

The remediation objective of variant 2 is less strict with the result that only industrial use is possible. So variant 1 have less restrictions for future land use.

- Remediation cost

Because of the longer duration for variant 1 (residential use), the remediation cost will be slightly higher.

- Cost of residual contamination

The residual contamination in the groundwater for variant 1 will be slightly lower than for variant 2.

Conclusions from MCA

After the scores were entered in the MCA (Figure 3-9), the difference in the total score turned out to be small (1713 and 1717). It can be questioned whether this MCA can be used to make a distinction between the alternatives. It seems as if it is more suitable to compare different types of remediation technologies, which are technically feasible, but vary significantly in duration and the environmental pressure they cause (e.g. dig and dump versus in situ). In this specific case the potential technologies which can be used are limited. However, slight differences occur depending on the alternative and it is useful in our view to list these differences (e.g. other duration of treatment) and what the sustainability consequences are of these differences.

3.4.4 Ecosystem services

The same four possible destination scenarios were used to estimate the potential value of ecosystem services for the Alvat site in Buggenhout, with the Nature Value Explorer (NVE; see Box 3.1) (www.natuurwaardeverkenner.be, Broekx et al., 2013). Ecosystem services are typically used to value the impact of land use changes. To allow for a fair comparison between scenarios, a uniform reference scenario is defined. As for brownfields the reference scenario is often badly defined on land use maps, we assume as if the site was used as a maize field. This decreases the additional value on ecosystem services (e.g. loss of agricultural production) but avoids overestimation of existing services related to temporary land cover (e.g. shrubs/trees present on the existing site).

Box 3.1. Nature Value Explorer (www.natuurwaardeverkenner.be)

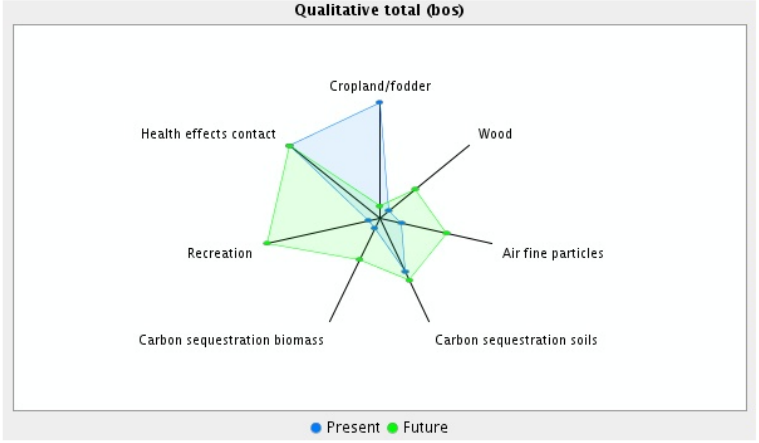
The Nature Value Explorer is an on-line tool, developed for the Flemish government, to explore the impact of ecosystem restoration on human welfare. Ecosystem services which can be valued are provisioning services as food production and wood production, regulating services as air quality and climate regulation and cultural services as recreation and health. Soil characteristics as texture, moisture and profile development play an important role in the calculations as these characteristics have a large impact on the potential delivery of provisioning and regulating services.

The tool is specifically suited to value the impact of land use change (nature restoration, urbanization). Users are required to deliver the location of the site, the size and the land use before and after the project. Additional information to be added depends on the individual service and includes soil characteristics, tree types, noise hindrance levels, amount of surrounding houses, etc.

Different valuation techniques can be applied:

- Qualitative scoring how important a service is in a specific area;
- Quantitative valuation of the importance of ecosystem services in physical terms (e.g. tonnes of C sequestration, amount of visits per year);
- Monetary valuation of the societal value.

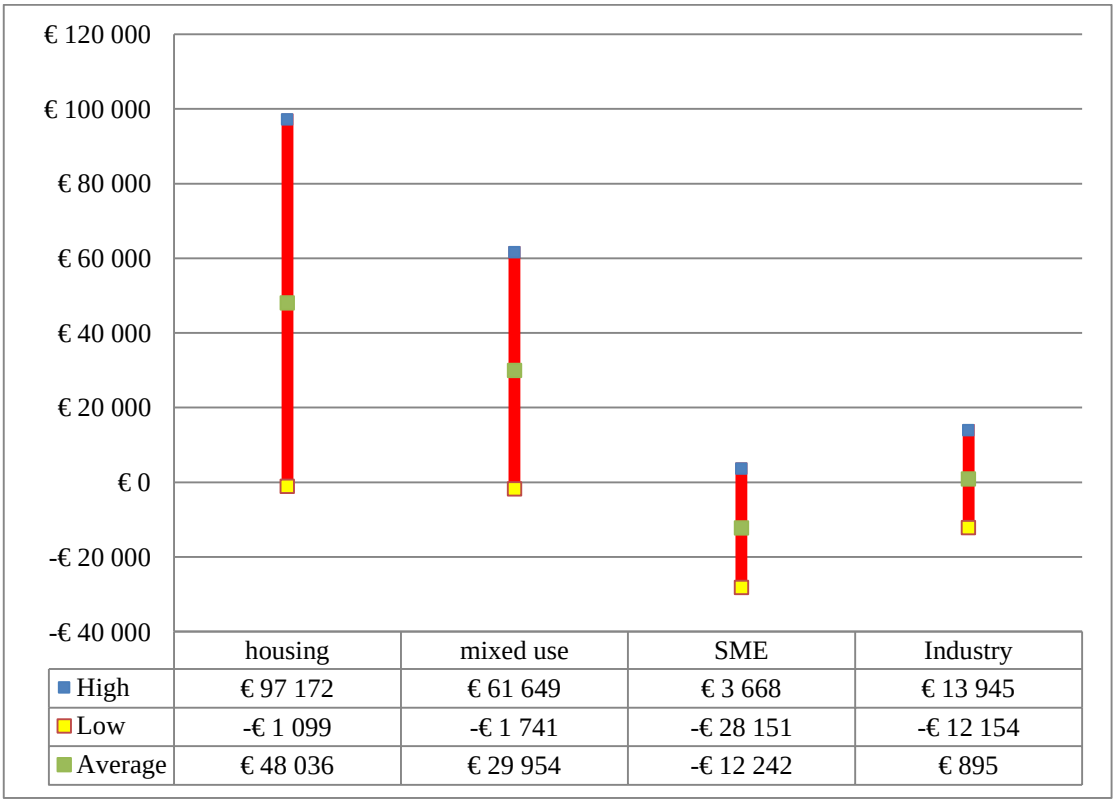
The tool is mainly suited for more rural areas. Ongoing research efforts are focusing on an urban version of this tool.



The NVE is actually used for estimating the ecosystem services provided by rural areas, therefore some conversions were required to estimate the ecosystem services for the Alvat case. These conversions are included in Table 3-8 below. For monetary valuation, see Figure 3-10.

Table 3-8. Conversion of classes used in the four designed scenarios to land uses usable in the Nature Value Explorer (NVE). Plant species are mentioned where relevant.

CLASS FROM REDEVELOPMENT SCENARIO	LAND USE IN NATURE VALUE EXPLORER	SPECIES IN NATURE VALUE EXPLORER
Industrial building	Urban	
Company building	Urban	
Residential house	Urban	
Other building	Urban	
Sealing	Urban	
Road	Urban	
Flower meadow	Grasslands and tall herbs	
Herbaceous lawn	Grasslands and tall herbs	
Water	Rivers and lakes	
Hedge	Woodland and forest	
Wood row	Woodland and forest	
Big tree	Woodland and forest	Oak (*Quercus robur*)
Small tree	Woodland and forest	Beech (*Fagus sylvatica*)



	housing	mixed use	SME	Industry
High	€ 97 172	€ 61 649	€ 3 668	€ 13 945
Low	-€ 1 099	-€ 1 741	-€ 28 151	-€ 12 154
Average	€ 48 036	€ 29 954	-€ 12 242	€ 895

Figure 3-10. Monetary valuation of ecosystem services (€/year). The values depict the incremental value compared to the reference scenario (maize field). Low and high estimates are estimated with low and high unit values for each service. Average values are the average of low and high values.

3.4.5 Biodiversity check

The biodiversity check was developed by the non-profit organization "Vrienden van Heverleebos and Meerdaalwoud" (VHM) with the purpose to provide insight to project developers and urban planners into the impact of spatial developments on the value of nature and biodiversity of a certain project site.

The main use of the tool is the estimation of the biodiversity value of an urban site and how this can be impacted by a more biodiversity friendly design. The tool is qualitative. A score is calculated for the situation before implementation of a project and the situation after the implementation of a project. A Dutch version of the tool can be found on www.biodiversiteitstoets.be.

Table 3-9 represents the selected sealing types and green shapes used for the 4 scenarios in the tool.

Table 3-9. Assumptions and results from the biodiversity check.

TOPIC IN BIODIVERSITY TOOL	**LAND USE TYPE**	**SCENARIOS**			
		Housing	**Mixed use**	**SME**	**Industry**
Roof surface buildings	House	Roof without vegetation	Roof without vegetation		
	Company building		Roof without vegetation	Roof without vegetation	
	Industrial building				Roof without vegetation
	Other building	Roof without vegetation	Roof without vegetation		
Sealing types	Sealing	Concrete clinker with permeable joint filling	Concrete clinker with permeable joint filling	Concrete clinker with permeable joint filling	Non-permeable sealing with non-permeable joint filling
	Street	Non-permeable sealing with non-permeable joint filling	Non-permeable sealing with non-permeable joint filling	Non-permeable sealing with non-permeable joint filling	Non-permeable sealing with non-permeable joint filling
	Dolomite				dolomite
	Parking				Grass tile
	Open ground	Open ground	Open ground	Open ground	Open ground
Open green shapes	Open green shape 1	Lawn	Lawn		Lawn
	Open green shape 2	Flower meadow	Flower meadow	Flower meadow	
Stony soil and walls					Pace plants/wall greenery

Water	Water	Artificial open water without vegetation	Artificial open water without vegetation	Artificial open water without vegetation	

Table 3-9. Continued.

TOPIC IN BIODIVERSITY TOOL	**LAND USE TYPE**	**SCENARIOS**			
		Housing	**Mixed use**	**SME**	**Industry**
Hedges and wood rows	Hedge				Woodrow
Trees outside forest with circumference < 1 m	Small tree	Lawn under tree group/ flower meadow under tree group	Sealing under tree group/ flower meadow under tree group	Sealing under tree group/ flower meadow under tree group	Lawn under solitary tree
	Big tree				
Trees inside forest with circumference < 1 m	Forest				Deciduous forest with well-developed herbaceous and shrub layer

Sealing index	**74**	**64**	**35**	**50**
Green shape index	**24**	**21**	**16**	**26**
Biodiversity index	**49**	**43**	**26**	**38**

3.5 Synthesis

A synthesis of the assessment results for the studied redevelopment alternatives is presented in Table 3-10.

Table 3-10. Synthesis of the assessment results and ranking of alternative redevelopment scenarios.

SCENARIO	**INSTRUMENT**											
	Economic Analysis, M€	**R**	**OVAM MCA**	**R**	**NVE, M€**	**R**	**Biodiversity check**					
							Sealing index	**R**	**Green shape index**	**R**	**Biodiver-sity index**	**R**
Housing dense	16	1	-	-	-	-	-	-	-	-	-	-
Housing	11	2	1717	2	48	1	74	1	24	2	49	1
Mixed use	2,3	4	-	-	30	2	64	2	21	3	43	2
SME	1,2	5	-	-	-12,2	4	35	4	16	4	26	4
Industry	7,6	3	1713	1	0,9	3	43	3	26	1	38	3

R: ranking of redevelopment alternatives.

For all instruments applied, the redevelopment alternatives assuming SME and housing had the lowest and highest ranking respectively.

3.6 Discussion

Different instruments were tested for the Alvat case. A stakeholder analysis gave an overview of the different viewpoints, how this can be incorporated in different redevelopment strategies and the potential direction of compromises that could lead to a feasible redevelopment of the site. Important bottlenecks are the ownership situation (curator, who is not willing yet to sell the site) and the potential destination (industry vs. residential), which has a lot of impact on the profitability. A potential compromise is to use the area for light industry/SME with a minimal pressure on surrounding residential areas. This option does not give the best results according to the assessments described above, but this mainly has to do with the assumptions on hardened surfaces for this scenario. Care has to be given of a nature friendly design in this alternative.

A risk assessment indicated that little differences occur on remediation targets and strategies for the different scenarios (residential vs industry). In case of industry the duration of the treatment might reduce a little. The OVAM MCA also gave very small differences between the redevelopment alternatives.

The economic assessment clearly confirms that Alvat was a blackfield, before the intervention of OVAM. After the intervention and given the fact that the site probably will not be redeveloped as a residential area, the profitability is a borderline case and still not guaranteed. This is also reflected in the limited interests from potential redevelopers (only one interested party). An update of the extent of the contamination is necessary to have a better idea of the actual situation.

The ecosystem services assessment and the biodiversity check both tend to favour the housing alternative. However, these conclusions are to a large extent driven by the assumptions made in the design of the area. Buildings in the housing alternative are mainly surrounded by grassland whereas buildings in the SME or industry alternative are mainly surrounded by hardened surface. A more “green” design of both alternatives could drastically change these results. Tools such as these are not suited to provide input for a scenario assessment on destination but are more useful in choosing between specific designs.

The usefulness of tools was also discussed with stakeholders during the stakeholder consultation. Most parties involved in the case (municipality, waterway administration, and redeveloper) had limited interests in tools that support decision making on sustainability. The focus of information lays on legal frameworks and existing procedures (zoning plans, environmental impact assessments, location nature protected areas, maps on water sensitive areas, etc.) that according to the stakeholders already capture a lot of the sustainability aspects. A stakeholder analysis is however considered as crucial. Stakeholders that were not directly involved in the case (Agentschap Ondernemen, OVAM) indicated a need to perform a more integrated planning of surface and sub-surface and across policy domains in which sustainability assessments can play an important role. The focus of research at this moment is on BREEAM-type of assessments (duurzaamheidsmeter) focusing on sustainability aspects during the entire planning process (initiative, planning & design, realization, maintenance & evaluation). An important challenge, stipulated by OVAM, still to be considered is how different types of sustainability assessments can fit into the entire planning process and how this can be better integrated in rules and regulation.

One of the identified problems in this case is that there are a lot of parties involved but that there is not a single party who manages the whole redevelopment process and acts as a process owner. At this moment, it is up to the private developer to find the necessary compromises and get all procedures started. This increases the risks for the private company and potentially slows down the entire process. Government administrations such as OVAM are careful in not intervening and distorting the private redevelopment market. An active role of OVAM in the acquisition and the remediation of a site is normally considered as the least preferable solution. When OVAM acts, costs are born by society, whereas preferably these costs should be borne by the market. However, attention needs to be paid that this position does not lead to a standstill in brownfields as Alvat.

The brownfield covenant, current legislation for Flanders, is an example on how different public authorities can work together and assist private parties to speed up redevelopment, without intervening in the private market. It gives developers the opportunity to sign a contract with the Flemish Government and other responsible public authorities about the realisation of a brownfield project. The aim is to enter in an agreement on mutual commitments in order to reduce uncertainties in the development process. Approved projects may also enjoy some financial benefits: exemption of registration fees for property transfers and exemption of the obligation of posting financial securities for soil remediation in case of transfer of contaminated land. Still it is not a guarantee for success as a covenant was signed in 2004, but this has not led to a successful redevelopment yet.

3.7 Advice for the Alvat case

From the stakeholder analysis it can be concluded:

- Differences in opinions exist between different stakeholders on how the site should be used (residential vs. industry). However, intermediate options (SME, mix SME-residential) are possible compromises. Important is that the municipality and the surrounding residential areas get a good view on what will happen on the site and how potential mobility issues due to additional traffic can be solved;
- The ownership situation (curator) is a potential bottleneck for further steps in the redevelopment. More pressure and evidence on the limited profitability can be exerted to sell the site for a symbolic euro. A combined effort of OVAM and the private redeveloper might be required.

From the SEES approach and the design process of potential redevelopment strategies it can be concluded:

- The site offers little opportunities from the subsoil. The realisation above ground should interact with the remediation strategy for the soil and groundwater pollution;
- A phased approach where the centre of the site is temporarily not built upon and occupied by a green area is a potential option to consider.

From the risk assessment, profitability analysis and sustainability assessments it can be concluded:

- Risk based targets and the choice in remediation technologies do not depend on the potential redevelopment strategy. The duration of treatment might be reduced in a SME/industry scenario;
- The site was correctly qualified as a blackfield. The investments in treatment by OVAM were required to attract private redevelopers and were not exaggerated, as the potential profitability in a SME scenario is still limited;
- The sustainability assessments focusing on ecosystem services and biodiversity are not very conclusive in distinguishing between scenarios. Specific measures can be taken in all scenarios (use of materials, amount and type of hardened surface, type of vegetation, etc.) to make the design more eco-friendly.

4 Fixfabriken site in Gothenburg, Sweden

The Fixfabriken site will be redeveloped from mainly being an industrial area incorporated into attractive parts of Gothenburg, into an area with mixed use, including residential use. The Fixfabriken site joined the Balance 4P project as a case study due to that the site has several activities which typically give rise to contamination problems and the Urban Planning Office at the municipality was in the phase of compiling information for suggesting a detailed plan for the area. Thus, Balance 4P was seen as having the potential to contribute to this process and the main stakeholders had an interest to participate, to contribute and to learn from the work within Balance 4P. The original research question in this case study was primarily how contamination and remediation issues can be brought in earlier into the planning process to achieve more sustainable redevelopment strategies, and how different instruments can support this.

The driver for redeveloping the site is a foreseen land use change, a private developer wants to turn a former industry (the Fixfabriken factory) into a residential area and the municipality in Gothenburg decided to consider a larger area in the development of a new detailed plan. The land in the area is owned by the municipality, the large private developer as well as a number of smaller land owners.

Within the Balance 4P project, a number of activities have been carried out in order to apply and assess different methods and tools that can provide input to and support the decision on a detailed plan. First, there have been a number of activities to identify sustainable redevelopment strategies considering the subsurface conditions:

- A student workshop on subsurface issues in urban design and student project works;
- A stakeholder analysis (quick-scan) for identifying participants for the first workshop;
- Stakeholder workshop 1: SEES – System Exploration Environment & Subsurface (see description of SEES in Box 2.1);
- Identification of alternative conceptual redevelopment strategies based on subsurface conditions and stakeholders' views.

In addition, sustainability assessments of identified redevelopment strategies have been carried out using three methods:

- SCORE (for brief description see Box 4.1);
- Mapping of changes in ESS (see Box 4.2);
- Social impact assessment (Box 4.3).

The results of the sustainability assessments were presented and discussed at Stakeholder workshop 2. All activities within the work with the Fixfabriken case study in the Balance 4P project were carried out during the period April 2014 – December 2015.

4.1 Site description

The Fixfabriken area is an area located in a popular part of Western Gothenburg. At present, it is mainly an area with industrial use (a factory, buss garage, tram hall and smaller enterprises) but it is now in the planning process for redevelopment into an area with a much more mixed use, i.e. residential housing, commercial buildings and public spaces. The bus garage will move in the coming 5 years and the tram hall is also likely move to another location in the future (10 – 15 years). There are mainly two landowners: the municipality itself and a private developer consisting of two large companies (HSB and Balder). The urban planning office of the municipality is in the process of changing and developing the detailed plan of the area to make it possible to redevelop into different land-uses than the present. Already a number of workshops and meetings have been carried out to explore what the neighbours and the existing companies prioritize and what they find valuable in the area. The potential of the area fits very well into the political objectives of the city: development of this area would not occupy any virgin ground, it is near to public transportation, it could potentially contribute with a good portion of residential housing, there is a possibility to complement the neighbouring area with now missing commercial and social services such as a food store and a sports facility, there is already a mixed use of the site and it is an attractive part of the city. Another prioritised political objective is integration, which delivers some more concern about how to achieve.

The site can be divided into four main areas: The Fixfabriken factory, the bus garage, the tram hall and the Karl Johansgatan area. Detailing on the site description is given in Garção (2015).

The **Fixfabriken factory** has had industrial activities since the 1940s. The soil at the Fixfabriken factory is contaminated to some extent by trichloroethylene, a chlorinated solvent. The present spreading conditions of the contaminants are to a large extent unknown. Archaeological remains are known in the area, although its boundaries are not defined.

The **Bus garage** property is owned by the municipality and is probably contaminated to some degree.

The **Tram hall** is operated by Göteborgs Spårvägar, which has a permit to be operating in the upcoming years. The municipality owns the property. Recently the company showed to the municipality its interest to keep operating the tram hall further after this deadline.

The **Karl Johansgatan area** includes the area that stands in between the road Karl Johansgatan, which is the main road serving the local neighbourhood, and the highway E45. It also includes the road Karl Johansgatan itself. Road infrastructures and traffic generate adverse effects, namely noise, air pollution and visual intrusion. Land use at the area includes two petrol stations, a residential area, parking lots, crossings and small green areas in between.

4.2 Stakeholder analysis

A quick-scan for a stakeholder analysis for the Fixfabriken area in Gothenburg was carried out. The main purpose of the stakeholder analysis is to get an overview over relevant stakeholders and to select stakeholders to invite to the Balance 4P workshop (the SEES workshop). For this stakeholder inventory, the general steps of the procedure for stakeholder analysis according to the Crosby method (Hermans, 2005).

The initial ample list of stakeholders was completed with the help of the representative from the Urban Planning department, see Table 4-1.

Table 4-1. List of stakeholders in the Fixfabriken area and their interest in the Fixfabriken area.

GROUP	SPECIFIC	GROUP'S INTEREST IN ISSUE
Municipality – planning functions	Urban Planning Office	A good urban development which abide to the local political objectives
	Recycling and Water Department	Planning of waste and water issues
	Property Management Department	Management of the municipality's land properties
	Parks- and Public Space Department	Planning and maintenance of green areas
	City District Administration	Development of the City District, child care, schools, inhabitants
	Traffic Planning Office	Traffic and infrastructure planning
Municipality – controlling functions	Environmental Department	Contaminated soil, noise, dangerous goods etc.
County administration – controlling authority, Social planning and cultural heritage	Samhällsbyggnadenheten	National interests in the area (*Riksintressen*): Energy distribution – gas pipe, Communication – road, shipping, harbour, Cultural heritage - Klippan and Kungsladugård, Other: health and safety, environmental quality guidelines
	Kulturmiljöenheten	Archaeology and ancient monuments
Land owners	Property Management Department	Development of property
	HSB/Balder - private land owner	Development of property
	Svenska Hus – small private land owner	No planned change
	xxx – small private land owner	No planned change
Today's companies	Swedgas	Owner to the gas pipe
	Triumfglass	Ice-cream company
	Friskis & Svettis	Gym facility
	Assa (previous name is Fix)	Manufacturer of metal parts for the textile industry – looking for new location, today renting the factory from HSB/Balder who are the new owner
	Photographer	
	Tram company (Spårvägen) – activities in the bus garage and the tram hall	Possibly want to stay at site – if possible to move tram hall underground.
	Kennedygymnasterna	Gymnastics association
	Mekonomen	Seller of car parts and tools
	and others…	

Table 4-1. Continued.

GROUP	SPECIFIC	GROUP'S INTEREST IN ISSUE
Today's companies	Swedgas	Owner to the gas pipe
	Triumfglass	Ice-cream company
	Friskis & Svettis	Gym facility
	Assa (previous name is Fix)	Manufacturer of metal parts for the textile industry – looking for new location, today renting the factory from HSB/Balder who are the new owner
	Photographer	
	Tram company (Spårvägen) – activities in the bus garage and the tram hall	Possibly want to stay at site – if possible to move tram hall underground.
	Kennedygymnasterna	Gymnastics association
	Mekonomen	Seller of car parts and tools
	and others…	
Future companies	Aim for most companies is to stay	
	Food store	
	Sports facility	
Inhabitants	Today's inhabitants	
	Future inhabitants	
	Sannaskolan School	
	Social housing	
Associations	BK Sandarna	Football club
	Not so many in the area but very many in the surroundings, e.g. Majorna, Sjöbergen	
	Potentially those that can use e.g. a future sports facility	
	Scooter association	
	Youth association	
Interest groups	Yimby – Yes In My BackYard	More residential housing, pro-densification
	Association for older inhabitants: "Gamla majgrabbar, gamla majtöser"	

For the Balance 4P project, a workshop for applying and testing the SEES working approach was planned. This workshop covered the whole Fixfabriken area and was broad workshop on chances and challenges associated from the subsurface on the aboveground development. The aim was to include representatives from all relevant subsurface qualities and all above surface layers, as well as researchers from the Balance 4P project. Table 4-2 shows the relevant stakeholders to invite and their position on the issue. The issue in this case is if they are willing to test the SEES working approach.

Other stakeholders not listed in Table 4-2, were invited: (1) a researcher from the University of Gothenburg (GU) who have been conducting research in urban development and interim uses of industrial areas, and (2) the architects associated with HSB/Balder whom have previously carried out studies/designs for Fixfabriken.

Table 4-2. The selected stakeholders and their position on the issue.[10] The stakeholders marked with light grey participated in the workshop. The stakeholder in bold were invited but did not participate for different reasons.

GROUP/ STAKEHOLDER	GROUP'S INTEREST IN ISSUE	RESOURCES	RESOURCE MOBILIZAT. CAPACITY	POSITION ON ISSUE
Urban Planning Office	A good urban development which abide to the local political objectives	Expertise, leverage (representing political decision-making)	High	++
Recycling and Water Department	Planning of waste and water issues	Expertise	High	+
Property Management Department	Management of the municipality's land properties	Expertise	High	++
Parks- and Public Space Department	Planning and maintenance of green areas	Expertise	Not checked	?
City District Administration	**Development of the City District, child care, schools, inhabitants**	**Expertise**	**Medium**	**+**
Traffic Planning Office	**Traffic and infrastructure planning**	**Expertise**	**Low**	**?**
Environmental Department	Contaminated soil, noise, dangerous goods etc	Expertise, leverage	High	-/?
"Samhällsbyggnads-enheten"	National interests in the area (*Riksintressen*): Energy distribution – gas pipe, Communication – road, shipping, harbour, Cultural heritage - Klippan and Kungsladugård, Other: health and safety, environmental quality guidelines	Expertise, leverage	Not checked	?
Kulturmiljöenheten	**Archaeology and ancient monuments**	**Expertise, leverage**	**Medium**	**++**
Property Management Department	**Development of property**	**Investment, leverage**	**High**	**++**
HSB/Balder - private land owner	Development of property	Investment, leverage	High	++

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- Group's interest in Issue: those interests that will be affected by the decision to be taken (just the most important ones);
- Resources: the resources the group possesses that can be used in the decision making (knowledge, information, leverage, money);
- Resource Mobilization Capacity can the group mobilize these resources quickly or slowly? This is important when looking at the dynamics of the decision making. If a decision needs to be taken quickly, but the resource (e.g. knowledge) can only be delivered slowly, this resource is of less importance than previously thought;
- Position on issue. The position should be examined. People can be strongly negative (- -), slightly negative (-) or slightly positive (+) or completely positive (+ +).

Table 4-2. Continued.

GROUP/ STAKEHOLDER	GROUP'S INTEREST IN ISSUE	RESOURCES	RESOURCE MOBILIZAT. CAPACITY	POSITION ON ISSUE
Swedgas	Owner of the gas pipe	Expertise	Not checked	?
Tram company (Spårvägen) – activities in the bus garage and the tram hall	Possibly want to stay at site – if possible to move tram hall underground.	Expertise, investment	Not checked	?
Yimby – Yes In My BackYard	More housing, pro-densification	Expertise	Not checked	?
Researchers Balance 4P	Research	Expertise	High	++
What! Arkitektur – architects	Input to design	Expertise	High/medium	+
Researcher GU	Research	Expertise	High	++

Note here that representatives the first three of the four identified stakeholder groups in the Balance 4P project were invited to the workshop:

- "knowledge" (knowledge institutes, universities);
- "regulators" (the different fields of regulation (environment, city planning, social and economic affairs) from municipality, region and environmental agency);
- "business" community (advisors, housing corporations, utility companies)
- "society" (social initiatives).

The fourth group could have been covered by e.g. the organisation Yimby ("Yes In My Backyard"), but time constraints lead to that they and some of the other identified stakeholder were not invited. It should however be noted that the community had already been involved by different types of activities outside the Balance 4P project. These activities have not been specifically considering remediation issues, but have rather been focused on land use and urban design issues. The activities that have taken place are workshop with schoolchildren from the nearby school, workshop with local small enterprises, workshop with local inhabitants, and a "walk-about" around the area for local inhabitants. The people that were present at the Fixfabriken SEES workshop organized by Balance 4P also took part in the above mentioned activities.

4.3 Generation of redevelopment alternative(s)

For identifying and designing sustainable redevelopment strategies, a number of activities were carried out within the Balance 4P project.

- Urban design students from TU Delft and Engineering students from Chalmers worked in a 2-day workshop to develop urban designs with remediation issues in focus. The workshop resulted in five different proposed designs for the Fixfabriken area that were presented to the municipality and the private developer;

- Three urban design students from TU Delft carried out their project works on in-depth studies of the Fixfabriken site, and proposed urban design alternatives;
- A workshop with stakeholders was carried out to apply and assess the SEES method for the Fixfabriken site;
- Stakeholders were asked for their preferences with regard to land use alternatives at the Fixfabriken site at the SEES workshop. These preferences were, together with more in-depth information on soil contamination, future plans for the site and archaeology further concretized into five conceptual redevelopment strategies that were used to apply a number of sustainability assessments.

Summary of results from the student workshop

The student workshop was carried out on April 23-25, 2015 in Gothenburg. Seventeen urban design students from TU Delft mixed with five engineering students from Chalmers. The workshop started with a site visit on Wednesday afternoon, presented by the representative from the municipality (Hanna Kaplan). Thursday morning started with presentations by the municipality (urban planning, soil contamination), the developer and a lecture on soil remediation technologies. In the afternoon, the students were working with vision making, and the first ideas were presented in the late afternoon. The last day of the workshop was hard work and in the late afternoon/evening final presentation to the clients (the municipality and the private developer).

The question posed to the students is how they view the future of the area in dealing with the soil conditions. The part of the assignment was to account in design options for contamination from the industry and garages, a large archaeological site and the connection to the city along the main road. The area around is a popular housing district with larger blocks of the early twentieth century with communal gardens in the courts. The students were asked to create a vision for the site with objectives and key interventions.

Five projects were presented: 1) We don't Fixfabriken[11], 2) FIXED remediation[12], 3) *Balanserade* Fixfabriken[13], 4) BINDING THE PATCHES[14], and 5) GO WITH THE FLOW[15]. Some general comments of the clients about all projects were:

- Good grip on the material and the site in a very short time;
- Perspective from the larger to the smaller scale, both in surface and subsurface themes;
- Good presentations, great visualization;
- Attention to the feasibility of the development in providing a phasing based on revenues is explored in two proposals, this is important for a developer;
- The projects also show how to work with the subsoil from a larger order of the area towards smaller scale public space, infrastructure or even building design;

[11] Amardeep Amarvasai, Barbara Bekhof, Jelle van Gogh, Juliska Wijsman and Lena Niël.
[12] Judit Gaasbeek Janzen, Nathali Cuotto, Felix van Zoest, and Sebastiaan Huls.
[13] Nirul Ramkisor, Robbie Anderson, Montserrat Pantoja and Janneke van der Leer.
[14] Mick van der Steeg, Willard van der Velden, Andrea Verni, Eelco de With and Ingrid Olofsson.
[15] Carmen Felix Aires, Jan ten Kate, Joop Stuijt and Rita Garção.

- Temporary use connected to the participatory approach is considered fruitful.

Students project work
The following student project works have been carried out and reported for the Fixfabriken case:

- FIXFABRIKEN – A study for future developments, by Felix van Zoest;
- Living the subsoil – A design from a subsoil perspective, by Barbara Bekhof;
- Uppleva FIXFABRIKEN!, by Janneke van der Leer.

All students' works used the subsoil as point of departure in their urban designs.

Summary of results from the stakeholder workshop 1: SEES tool
The workshop was carried out on May 26, 2014, at Chalmersska huset. There were three main objectives of the workshop:

- to apply and evaluate the SEES approach on a Swedish case together with the actual stakeholders;
- to deliver input on subsurface issues to the ongoing work in the Fixfabriken area;
- to discuss strategies that can be further analyzed in the Balance 4P research project.

The workshop was attended by different "subsurface experts" from the Property Management Department of the City of Gothenburg[16] and "aboveground experts" both from different functions from the City of Gothenburg[17] as well as the private developers' project leader and architects. In total there were present 13 persons, including 2 facilitators, 8 stakeholders and 3 other participants (2 from project team and 1 from Gothenburg University). See also Table 4-2 for details.

The project area was presented by the Urban Planning Department and the private developer. Afterwards, the subsurface experts presented the following subsurface themes for the project area:

- Civil Constructions: archaeology, cables and pipes[18];
- Geotechnics and water: Hydrogeology, soil subsidence;
- Soil: soil contamination, landscape morphology.

After each presentation, the yield per "layer" (people, metabolism, building, public space, networks) was discussed and noted in the SEES matrix, see Figure 4-1.

[16] The expert from the County Administration got ill and had to cancel his participation.
[17] The functions present from the City of Gothenburg were: the urban planning department, the environment department, the recycling and water department. The city district administration cancelled and the Traffic planning office did not respond to the invitation.
[18] Both experts cancelled – summaries by workshop facilitator + representative from the Urban Planning department instead.

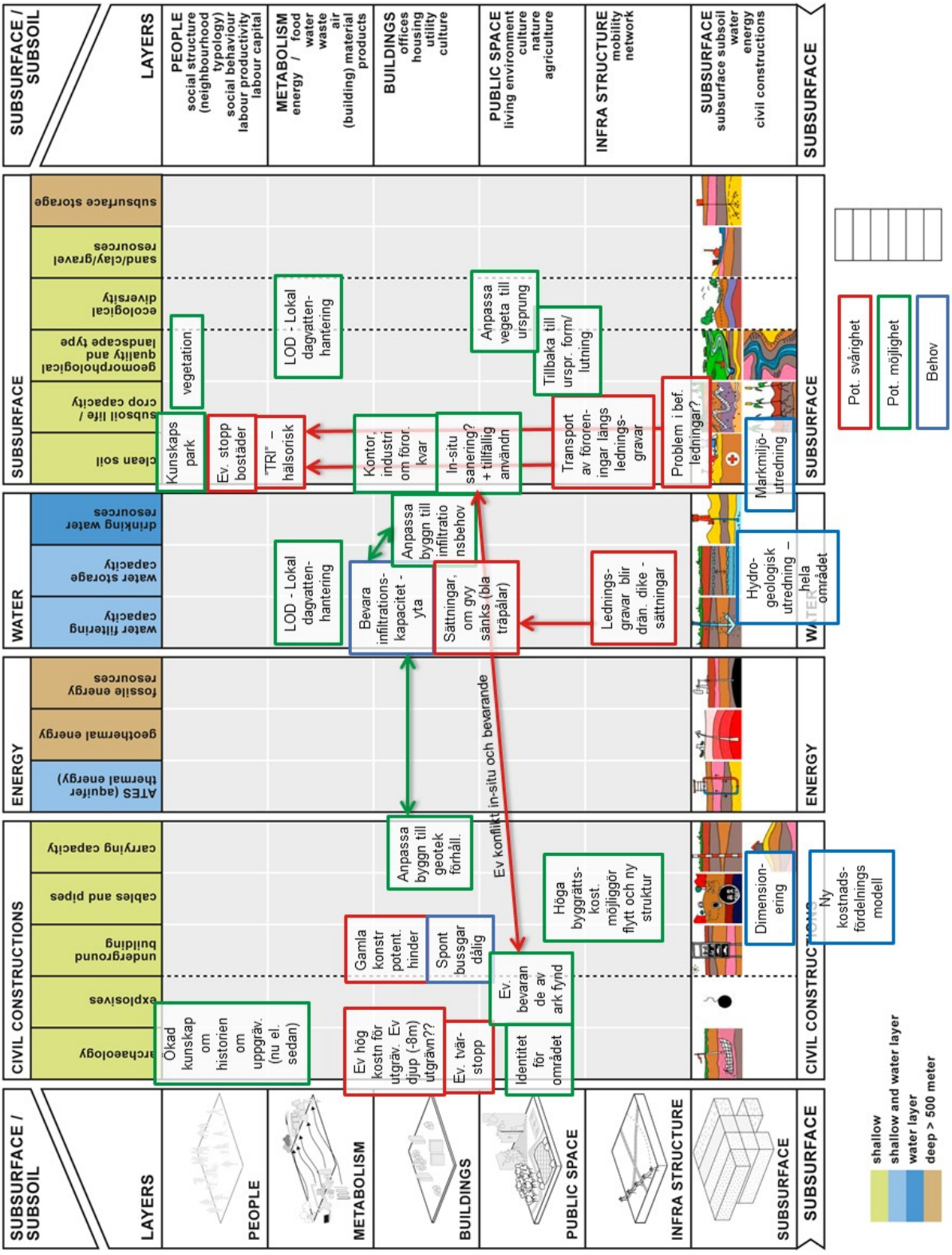


Figure 4-1. The result of the discussions at the first stakeholder workshop in the SEES matrix.

The main areas that were discussed during the workshop are the following:

- The Sandarna archaeological site: Early Stone Age settlement (6,000 years B.C.) and more recent settlement from Late Stone Age (3,000 years B.C.):
  There are interesting archaeological remains from the Stone Age in parts of the area which has a very high cultural/historical value. This was seen both as an opportunity as well as a threat. It could create an identity for the area and a full excavation could enhance knowledge about this early settlement in Sweden but at the same time, it could hinder the development of new buildings by making it expensive to build and it could also be in conflict with a number of in-situ remediation technologies;

- The old Fixfabriken (ASSA) and problems with contamination of Trichloroethylene (TRI):
  The full picture of contamination is unclear at the site although there are some data from different types of activities in the full area. The largest concern here is the known use of chlorinated solvents in the old Fixfabriken building (now ASSA) combined with the unknown spreading and present and future risk to humans (and the environment). An issue that was raised is the possible transportation of contaminants off-site along existing pipes and cables, how the spreading situation is and if there potentially is a present problem in the existing pipes;

- Precipitation infiltration and soil subsidence, damages on old constructions:
  The site has a different geological and hydrogeological situation than what is normally found in Gothenburg. Glacio-fluvial deposits and historically variable sea-level has given rise to layers of more conductive material, sand inter-bedded in the clay deposits, and parts of the area is important as an infiltration area. The need for an overview hydrogeological investigation was pointed out since exploitation that would cause a lowering of the groundwater table in this area can result in soil subsidence in the surrounding parts and thus large maintenance costs. The potential to adapt future building complexes to the hydrogeological and geotechnical conditions were discussed, but there was no time to further explore it during the workshop;

- Attractive area and high land value, gives possibilities to restructure cables and pipes:
  The Fixfabriken area is an area located in a popular part of Western Gothenburg and the land value is potentially very high. It is estimated that it will be high enough to allow for a new structure of the present pipes and cables in the ground – the cost would be outweighed by the potential benefits.

With regard to feedback on the applied SEES-method, it was concluded that the competencies that met during the workshop seldom get the chance to sit together and discuss and that the method had a high potential for use in other projects as well. Unfortunately, some experts were missing both representing the subsurface and the different layers of the built environment/city. For example, the representative from the city district administration would have been able to include the social/people perspective more clearly, but the participation was cancelled last minute.

After discussing the challenges and opportunities in the Fixfabriken area by applying the SEES-method, the participants were asked to evaluate the workshop and the possibilities presented. Eight representatives of the stakeholders and two of the external participants (two of three) answered the questionnaire, which included three straight questions and one additional to gather comments.

The questions and answers obtained are presented in Table 4-3. What concerns short reflections by the participants (question 4), it can be considered that, in general, respondents made comments on what can be improved, competences that were missing, important issues that were never raised, stages when SEES approach is applicable, adjustment to Swedish conditions, and expectation of different participants 'perspectives if having real situation instead of a research project. Table 4-3 also provides the full comments.

Table 4-3. Answers to the questionnaire on the stakeholder workshop 1.

QUESTION	**RESPONDENTS**	**DEGREE OF AGREEMENT** Not at all					To a very high degree	
1. Did you receive any new information about the Fixfabriken site that is helpful in your continuing work?	Stakeholders (8 persons)		I 12.5%		II 25%	III 37.5%	I 12.5%	I 12.5%
	Other participants (2 persons)						II 100%	
2. Is this a working approach you would like to apply in other similar projects?	Stakeholders (8 persons)		I 12.5%		I 12.5%	I 12.5%	III 37.5%	II 25%
	Other participants (2 persons)						I 50%	I 50%

Table 4-3. Continued.

QUESTION	RESPONDENTS	DEGREE OF AGREEMENT Not at all — To a very high degree						
3. Would you recommend this working approach to your colleagues?	Stakeholders (8 persons)		I 12.5%		I 12.5%	I 12.5%	III 37.5%	II 25%
	Other participants (2 persons)						I 50%	I 50%
4. Short reflections:	Stakeholders (8 persons)	•"Should be clear that this is about subsurface conditions which should be combined with other types of competences in the planning. Greatest benefit is to identify issues that collide/work together since these competences seldom meet otherwise. Basis for better processed analyses. Would have been valuable to have Park and Nature present." •"Missing: archaeology, cables and pipes, municipal district committee. Missing competences due to that it is a research project, people would have prioritized differently if "sharp". I believe in early trans-disciplinary discussions. The start-up meeting for a program work or working with a detail plan are similar but often more problem-oriented. The benefit that the discussion is lead through a matrix is that more perspectives are lifted forward and that also benefits/possibilities must be discussed." •"Good with an early contact with the developer, but should (formally) have been earlier. Several completely unrealistic strategies in the options." •"Some information was good to receive in an early stage, but it is a little too much "waste"-time in this process and uncertainties. Would have been better with some really good prepared lectures of about 30-45 minutes on 1) archaeology, 2) geotechnics, 3) cables and pipes. Now there are still many uncertain factors. More investigations are needed before this is useful." •"Perhaps more important for other competences, but important with an insight to and understanding for this. There is on the other hand so many different factors that comes into play that it feels difficult to take this into consideration all the time. Usually shows only when a problem arises, could have been interesting if this "planning in advance" leads to cost reductions."						

Table 4-3. Continued.

QUESTION	RESPONDENTS	ANSWERS
4. Short reflections (continued):	Other participants (2 persons)	•"I think all relevant questions were touched upon but would have liked to see a more clear connection to the social dimension for different problems and solutions. Maybe this could be the Swedish adjustment. From an ecological point of view it would be good to have something more on the function of the soil, before/after and the ecosystem services that are generated by the soil as such." •"Personally I would have liked to get more knowledge about the earlier and the present use of the area, and about the workshops arranged by the developer – but I could of course checked that myself. I understand it is impossible to raise all thinkable perspectives in one occasion. It would have been possible to imagine more info on the historic cultural value of the buildings and the small companies and associations' economy etc. but – as already said – at another occasion. Good to concentrate."

Summary of identified conceptual redevelopment strategies

After discussing the challenges and opportunities in the Fixfabriken area in the first stakeholder workshop, the participants were asked to rank what strategies they would prefer with regard to land use and remediation strategy in the different parts of Fixfabriken. It was clearly pointed out that it was for the research project and not part of the process lead by the Urban Planning Department. Despite this, some participants were unwilling to reply due to the early stage and data unavailability, and due to the inclusion of remediation strategies that are not frequently applied in Sweden today (e.g. in-situ technologies). Still, these opinions were used for identifying redevelopment strategies for sustainability assessment together with more in-depth interviews with the expert from the County administration on the archaeological findings in the area, consultation of the soil remediation expert at the real estate office together with consultant reports, and also consultation with the representative from the urban planning office at the municipality. The work is presented in detail in Garção (2015). Along with the reference alternative, five redevelopment strategies were identified and summarized below (see also Figure 4-2), detailed for each of the sub-areas at the site: (1) the Fixfabriken factory; (2) the bus garage; (3) the tram hall; and (4) the road Karl Johansgatan. In these alternatives, the urban design is not in focus but rather the land use in general in combination with potential remediation strategies.

Reference alternative

The reference alternative corresponds to the present situation, keeping a relatively underused area within an attractive part of Gothenburg.

Alternative 1
The Fixfabriken factory is demolished. The existent filling material beneath the buildings and the superficial part of the underneath layer are dug out. New buildings for residential use with some commercial areas in the ground floors are then constructed, starting 5 years from now. Redevelopment occurs during 2 years. Housing heights are 4-7 floors, with a mix of rental and condominium apartments. The excavated contaminated materials are not further treated but are transported off-site to final disposal, possibly with some treatment at the disposal site.

The Bus garage is demolished and the existent filling materials beneath the buildings and the superficial part of the underneath layer are dug out. New buildings for residential use, with commerce/offices/services at the ground floor, are then constructed, starting 8 years from now. It is assumed that the development occurs in two stages. The total redevelopment period is 3 years. Housing heights are 4-7 floors, with a mix of rental and condominium apartments. The excavated contaminated materials are not further treated but are transported off-site to final disposal, possibly with some treatment at the disposal site.

The Tram hall is kept as it is. No remediation action is taken, unless any extreme hot-spots are found in the coming investigations.

The existing petrol stations at the street Karl Johansgatan are demolished, and the present residential area is kept. New buildings for industrial and office use are then constructed, starting 10 years from now. It is assumed that the redevelopment occurs in several stages, during 8 years. No action is taken in the remaining area along the street Karl Johansgatan. Regarding remediation action, the filling materials beneath the places to be reconstructed are dug out. The excavated contaminated materials are not adequate to be used on-site and are transported off-site to final disposal, possibly with some treatment at the disposal site.

Alternative 2
The Fixfabriken factory is demolished. In the northern part the existent filling materials beneath the buildings and the superficial part of the underneath layer are dug out. New buildings for residential use are then constructed in the northern part, starting 5 years from now, and during 2 years. Housing heights are 4-7 floors, with a mix of rental and condominium apartments. The excavated contaminated materials are not adequate to be used on-site and are transported off-site to final disposal, possibly with some treatment at the disposal site. The southern part becomes a green area to preserve and emphasize the historical importance of the site. The upper soil layers are remediated through soft techniques (e.g. phytoremediation), i.e. no excavation unless any extreme hot-spots are found in the coming investigations. This allows a lower disturbance of the underneath layers, thus lower probability of affecting the known archaeological remains from the Early stone age culture ”Sandarna settlement” (6000 B.C.) and prehistoric settlements from Neolithic age (late stone age), and eventual remains of an ancient military camp (1500s-1600s A.C.).

The Bus garage is developed in the same way as described in Alternative 1. The Tram hall is treated as described in Alternative 1. The Karl Johansgatan area is handled in the same way as described in Alternative 1.

Alternative 3
The future land uses in this alternative are developed quite differently from alternatives 1 & 2 and also the remediation strategy is different. Whereas Alternatives 1 & 2 emphasize excavation, this alternative focuses on no excavation, but instead using surface cover, hot-spot in-situ remediation and active ventilation of new constructions to prevent vapors in-door to manage contamination.

Consequently, when the Fixfabriken factory is demolished, foundations and sub-surface structures are left untouched to disturb the sub-soil as little as possible. These structures are instead ventilated to manage contamination. Around buildings, in-situ and soft techniques (e.g. phytoremediation) are potentially applied in combination with surface cover. New buildings are constructed on top of existing sub-soil structures. Ground floor is ventilated to manage contamination and used as commercial space. 2 floors of apartments are built on top of these for residential use, with a mix of rental and condominium apartments. In addition, 20% of the apartments are subsidized for low-income families. Development starts 5 years from now, and is carried out during 2 years.

The Bus garage is demolished without digging out the existent filling materials beneath the buildings. New buildings are constructed on top of the surface with piling where needed, to disturb the sub-soil as little as possible. New buildings are constructed on top of existing sub-soil structures. Ground floor is ventilated to manage contamination and used as commercial space. 3-4 floors of apartments are built on top of these for residential use, with a mix of rental and condominium apartments. In addition, 20% of the apartments are subsidized for low-income families. Around buildings, in-situ and soft techniques (e.g. phytoremediation) are potentially applied in combination with surface cover. Development starts 4 years from now, and is carried out during 2 years.

The Tram hall is kept as it is. No remediation action is taken, unless any extreme hot-spots are found in the coming investigations.

The Karl Johansgatan area is developed in the same way as described in Alternative 1.

Alternative 4
Fixfabriken factory is handled in the same way as described in Alternative 1.

The Bus garage is demolished and the existent filling materials beneath the buildings and the superficial part of the underneath layer are dug out. A new tram hall is constructed, starting 8 years from now, and during 2 years. The excavated soil is handled in the same way as described in Alternative 1. Different future land uses is thus the main difference between Alternative 1 and 4.

The Tram hall is demolished and the existent filling materials beneath and eventually the superficial part of the underneath layer is dug out. New buildings for residential use (a mix of rental and condominium apartments), with commerce/offices/services at the ground floor, are then constructed, starting 10 years from now. It is assumed that the redevelopment occurs in 2 different stages, in a total of 3 years. The excavated contaminated materials are not adequate to be used on-site and are transported off-site to final disposal, possibly with some treatment at the disposal site.

The Karl Johansgatan area is handled in the same way as described in Alternative A1.

Alternative 5
This alternative keeps the existing constructions at the area to a highest extent, namely Fixfabriken and the tram hall.

Buildings and uses (industrial and offices) at Fixfabriken factory are kept as they are. Buildings are renovated to assure an adequate indoor air quality, namely through active ventilation. The space is used as incubator for new businesses and social entrepreneurs. Depending on further investigation of the soil contamination in the area, in-situ remediation might be carried out if there are any hot-spots / left source areas. This is assumed to occur 2 years from now.

The Bus garage is developed in the same way as described in Alternative 1, but with housing heights of 7-15 floors, with a mix of rental and condominium apartments. In addition, 20% of the apartments are subsidized for low-income families.

The Tram hall is treated as described in Alternative 1. The Karl Johansgatan area is handled in the same way as described in Alternative 1.

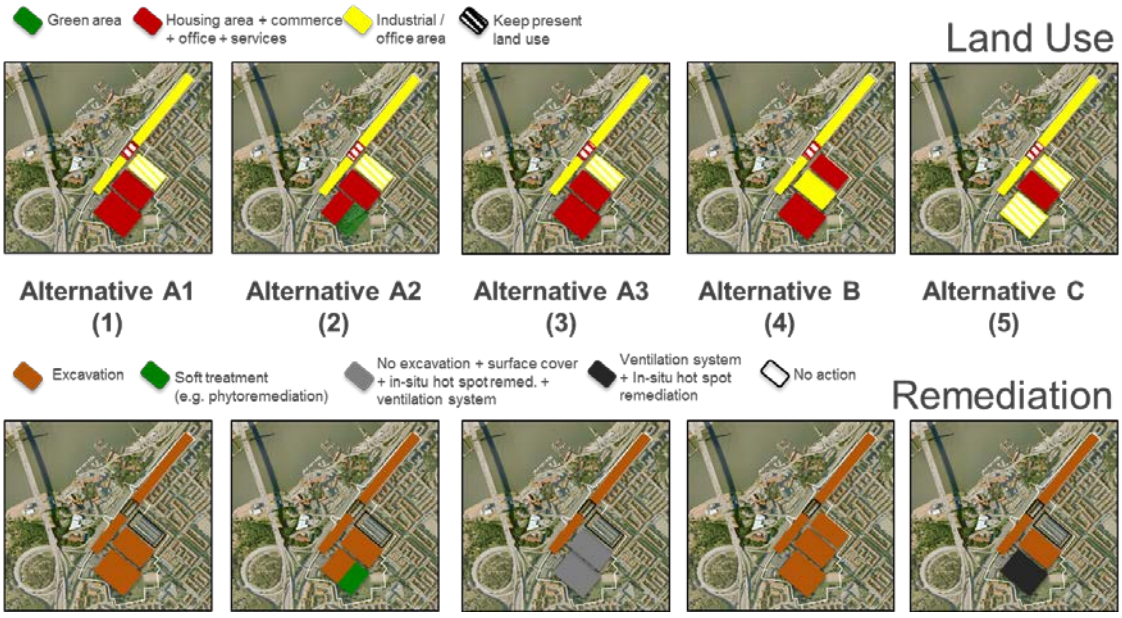


Figure 4-2. Overview of redevelopment strategies at the Fixfabriken site. From Garção (2015).

4.4 Assessments of project redevelopment alternatives

Three different approaches were selected for sustainability assessment of the identified alternatives: the SCORE tool, mapping of Ecosystem services (ESS), and Social Impact Analysis (SIA). All methods uses an evaluation relative to the reference alternative, i.e.

the assessments try to say something about how a change from the present situation to one of the identified redevelopment strategies will affect different aspects. The results were presented at the second stakeholder workshop on 13th of October, 2014.

4.4.1 The SCORE tool – Sustainable Choice of Remediation

The SCORE framework (Rosén et al., 2013, 2015) aims to assess the sustainability of remediation strategies with regard to criteria in the environmental, the socio-cultural and the economic domains of sustainability (see Table 4-4). It has been developed to support decisions on remedial strategy and not to support decisions on land use and urban planning. Primarily the social domain lacks aspect of sustainable urban development.

In the economic domain, costs and benefits are measured quantitatively in monetary terms using Cost-Benefit Analysis (CBA) addressing the *Social profitability* criterion (Rosén et al., 2008, Söderqvist et al. 2015). In the environmental and socio-cultural domains, qualitative scores are assigned to a number of key criteria. The effect of a remediation alternative on each criterion is scored between -10 representing "very negative effect" and +10 representing "very positive effect". A score of 0 represents "no effect". All effects of the analysed remediation alternatives are measured relative to the effects of a reference alternative, e.g. when no remedial action is taken.

Table 4-4. Key criteria of the SCORE framework by Rosén et al. (2015).

ENVIRONMENTAL DOMAIN	SOCIO-CULTURAL DOMAIN	ECONOMIC DOMAIN
• Soil • Flora and fauna • Groundwater • Surface water • Sediment • Air • Non-renewable natural resources • Non-recyclable waste	• Local environmental quality and amenity • Cultural heritage • Equity • Health and safety • Local participation • Local acceptance	• Societal profitability

The SCORE framework is based on Multi-Criteria Decision Analysis (MCDA) and uses a linear additive model to rank the remediation alternatives, in combination with a non-compensatory method to identify those alternatives which are regarded as not leading towards sustainability. The scores of each criterion are added and integrated, together with the results of the CBA, into a normalized sustainability index. The most sustainable alternative is the one which generates the highest sustainability index. The uncertainties in the MCDA model are analysed using Monte Carlo simulation (Rosén et al. 2013, 2015). The details of the SCORE analysis for the Fixfabriken site are presented in Garção (2015).

Box 4.1. SCORE – Sustainable Choice of Remediation.

SCORE

SCORE (Sustainable Choice of REmediation) is a multi-criteria decision analysis (MCDA) method which allows for transparent assessment of the sustainability of remediation alternatives at contaminated sites. SCORE evaluates the performance of alternatives relative to a reference alternative in the economic, environmental and social sustainability domains, following the view of sustainable development given by, for example, the United Nations (2012). SCORE is unique in that it (1) integrates social and environmental analyses with a quantitative economic analysis, (2) evaluates remediation with respect to strong and weak sustainability, (3) allows weighting of the sustainability domains to reflect different views of sustainable development, (4) provides a gross set of non-overlapping key performance criteria, and (5) provides a full uncertainty analysis of MCDA outcomes. The SCORE method has been programmed into an Excel tool and is planned to be available for use in 2015 (Rosén et al., 2015).

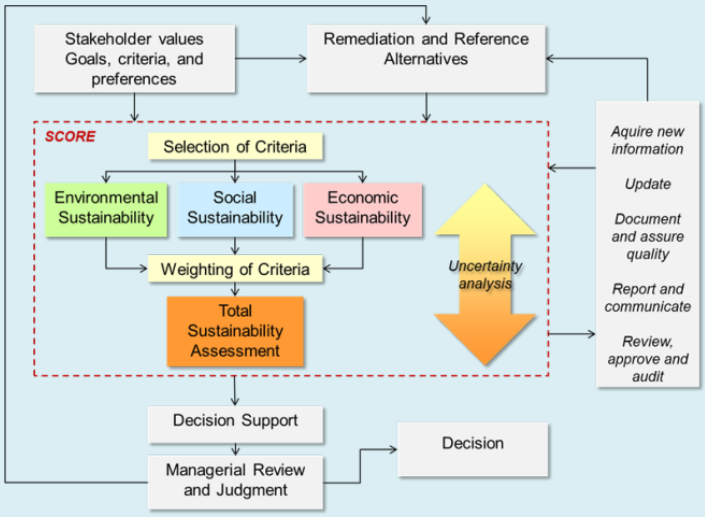
What is needed?

- Excel based SCORE tool;
- An assessment team with expert judgment and access to site data and local knowledge;
- Collaboration/communication with stakeholders.

How it works?

The following eight steps make up the SCORE method:

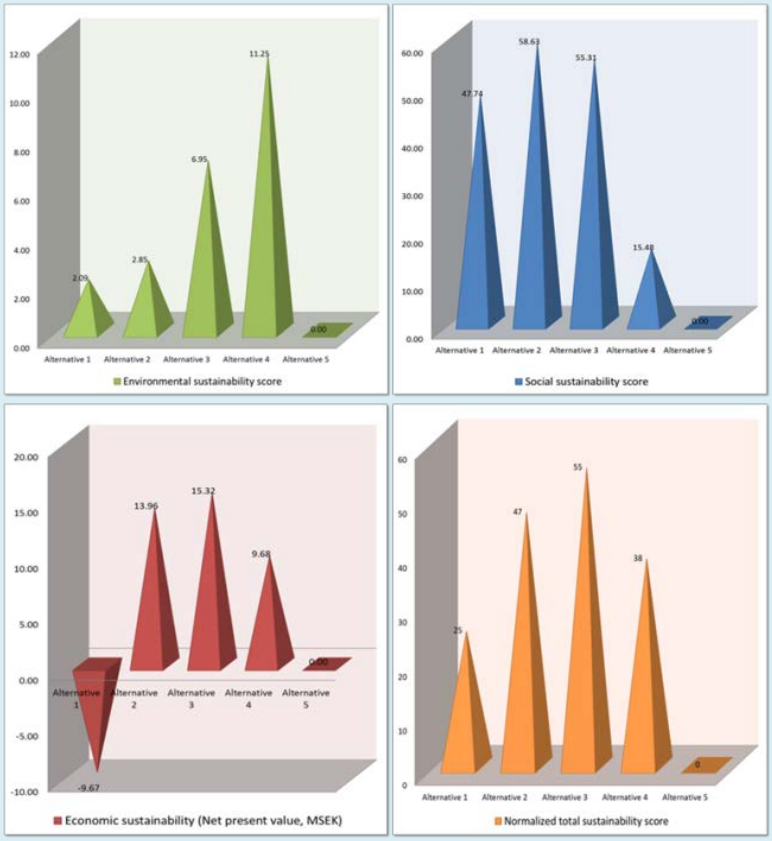
1. Present remediation alternatives and reference alternative;
2. Select the relevant SCORE sustainability criteria;
3. Perform an environmental sustainability assessment;
4. Perform a social sustainability assessment;
5. Perform an economic sustainability assessment, by means of a Cost-Benefit Analysis (CBA);
6. Assign weights to the selected set of SCORE sustainability criteria;
7. Run a Monte Carlo simulation as part of the uncertainty analysis;
8. Assess overall sustainability and evaluate results.



The SCORE decision support framework.

What is the result?

Results from within each domain are presented, along with a calculated total (normalized) sustainability score. The normalized score has a value from -100 to +100, where a positive score indicates that the alternative leads towards sustainable development. The results also reflect the number of the positive and negative effects due to remedial action and due to the change in source contamination. The results also include distribution analysis in the economic part of the sustainability assessment. SCORE identifies compensatory effects on both the domain and criteria levels. It is up to the assessment team to define what type of sustainability, in terms of strong and weak sustainability on domain and criteria-levels, that is required for the particular assessment. The uncertainty interval for each alternative's score is presented and the alternative with the highest probability of being the most sustainable is identified. A sensitivity analysis shows which criteria contribute the most to the total variance of each sustainability score.



Example of SCORE results: scores on domain level and the total sustainability score.

When to use SCORE?

The implementation of SCORE should take place in the risk evaluation phase of a remediation project, i.e. when to decide what intervention is most suitable (sustainable). SCORE was developed to be used to assess remediation alternatives with the same, fixed future land-use scenario. The method has not been developed for use in urban planning for comparing e.g. the development of an industrial area into a residential area with the development of the same area into a recreation area. In the Fixfabriken case study, the SCORE tool has been applied in the plan phase (or scenario appraisal phase), and this application is discussed in Garção (2015).

4.4.2 Mapping of Ecosystem Services (ESS)

A qualitative mapping of changes in Ecosystem services with regard to the five alternatives was carried out, based on the following principles: An inventory of existing ecosystem services with regard to two typologies: i) Urban Ecosystem Services (Gomez-Baggethun et al., 2013) and ii) Soil Ecosystem Services (Finvers, 2008) and a qualitative valuation of changes (assessment ex-ante and assessment ex-post) using the following scale, see Table 4-5:

Table 4-5. Scale used for qualitative valuation of changes.

QUALITATIVE VALUATION OF CHANGES	
-1	Land use has a negative impact on supply of ESS
0	Land use implies no supply of ESS
+1	Land use has a significantly negative effect but allows for some supply of ESS
+2	Land use has a somewhat negative effect on the supply of ESS
+3	Land use is not affecting the supply of ESS

The total change of each alternative is summarized by looking at the change on each type of ESS. A detailed description of the method and its application for the Fixfabriken site is given in Ivarsson (2015).

Box 4.2. Mapping of changes in Ecosystem Services.

What is needed?

Mapping of ecosystem services requires a good knowledge of the natural conditions at the remediation site itself, as well as in adjacent or remote areas also affected by the remediation actions. Sources of information could be monitoring data from regulating agencies or municipalities, maps and/or photos of the remediation site, first-hand information gathered during personal visits or information elicited through interviews of experts with local knowledge. Other important sources of information are reports from geological and archaeological surveys from the area.

How it works?

The method has three principal steps, Identification, Quantification and Valuation. The first step implies identification of the relevant ecosystem services at the remediation site (and in affected adjacent or remote areas). The process is guided by a “check list” of ecosystem services that is chosen from existing compilations of relevant ecosystem services. In the present case the “check list” is made up of soil and urban ecosystem services gathered from the literature. The second step, Quantification, involves a status assessment of the ecosystem services at the remediation site given the present land use. It also involves an assessment of the change in supply of ecosystem services that can be expected as a result from the remediation project. The quantification is supported by indicators reflecting the change in supply of ecosystem services in terms of actual biophysical changes, e.g. area of removed/added vegetation, volumes of excavated polluted soil etc. The changes in supply of ecosystem services are given qualitative scores that are summed in order to deduce the overall impact (positive or negative) that can be expected from each remediation option. The last step, Valuation, has not been performed in the present study. It involves monetary

valuation of the changes in supply of ecosystem services and brings additional weight to the analysis in its role to support decision making with regards to different remediation options, see below regarding CBA.

What is the result?

The result from the qualitative analysis is as a map of the benefits and costs in terms of welfare changes connected to changes in provision of ecosystem services accruing to a specific remediation alternative. This type of benefits and costs seldom occur in traditional cost-benefit analysis which traditionally deals with the financial aspects of a remediation or exploitation project. The qualitative scores can be used together with financial input in decision support systems which are designed as multi criteria analysis (MCA) tools. If the effects are also monetized, the result can be readily included in classical CBA.

When to use?

The method can be used to inform decisions on any exploitation or remediation project involving changes of nature values, hydrology or ecosystem function, which might affect the wellbeing of people.

4.4.3 Social Impact Analysis (SIA)

The City of Gothenburg offers different tools that can be used in urban planning and design, and one of the aspects lifted forward in urban planning and design is social sustainability. Two tools have been developed for the City of Gothenburg to aid in urban planning: a social impact analysis (SIA)[19] and a child impact analysis[20]. For the Fixfabriken site, the SIA tool was used in order to analyse the redevelopment alternatives from a social sustainability perspective that would include aspects of urban planning and design. In practice, this tool is used to map the current situation, the needs and to analyse the impacts of the suggested detailed plan. In the Balance 4P project, we choose to use the tool to map the impacts of the alternative against the current situation (i.e. the reference alternative). The results of the analysis are presented in Appendix B.

Box 4.3. The Social Impact Analysis tool for urban planning developed by the City of Göteborg.

Social Impact Analysis (SIA)

The City of Göteborg offers different tools that can be used in urban planning and design, and one of the aspects lifted forward in urban planning and design is social sustainability. Two tools have been developed for to aid in urban planning: a Social Impact Analysis (SIA)[21]

[19] http://goteborg.se/wps/wcm/connect/8439c0bc-9996-44a8-88ca-cbf89a197b1a/OPA_R_sartryck_SKA_WUF.pdf?MOD=AJPERES, access date: 2014-11-19
[20] http://goteborg.se/wps/wcm/connect/171d705a-cfa7-48fe-b788-c0b18eac593e/OPA_R_BKAenglish.pdf?MOD=AJPERES, access date: 2014-11-29
[21] http://goteborg.se/wps/wcm/connect/8439c0bc-9996-44a8-88ca-cbf89a197b1a/OPA_R_sartryck_SKA_WUF.pdf?MOD=AJPERES, access date: 2014-11-19

and a Child Impact Analysis[22] (not described here). The SIA tool application in Balance 4P is presented in more detail in Appendix B.

What is needed?

The SIA matrix, knowledge on the current situation, the ambitions for the site and the plan to be investigated, experts with regard to social impacts, potentially stakeholders, and the background material for the SIA tool (only available in Swedish).

How it works?

The SIA tool is displayed in the form of a simple matrix, which takes four different social aspects into consideration: Cohesive city, Interactions, Everyday life and Identity. Those aspects are in line with the political objectives of the City of Göteborg and are analysed with regard to five different scales: Buildings and places, Neighbourhood, District, and City.

What is the result?

The result is a qualitative analysis of the social impacts of a plan, mapped with regard to different scales. The result is displayed in the matrix, but the most important result is the communication and the analyses needed to fill in the matrix.

When to use SIA?

It is typically used as an inventory tool to check what there is, what is needed and the anticipated impacts of the detailed plan. In the Balance 4P project, the SIA was used as a tool to investigate the social impacts with regard to alternative redevelopment strategies against the current situation (i.e. the reference alternative). Here, the impacts were also qualitatively valued in order to compare alternative strategies.

4.4.4 Stakeholder workshop 2: Presentation and discussion of results

The second stakeholder workshop was carried out on October 13th, 2014, at Chalmersska huset, Gothenburg. The same stakeholders as for the first workshop were invited and in addition there was an expert invited who had long experience of remediation issues in connection to planning. There were six stakeholders present at the workshop, two each from the Urban Planning department, the Real Estate department and from the department dealing with water and waste. In addition, there were five researcher present, four from the project and one external (same as workshop 1).

The overall aim of the workshop was to present the conceptual redevelopment strategies together with the results of the sustainability assessments described above, as well as to discuss the advantages and the difficulties in applying those methods. The research team also aimed for discussing a ranking of the redevelopment strategies based on the different analyses. However, the ESS analysis was not fully completed (only for one alternative) at the time for the workshop, and time was too limited to have time to both present all the results and to fully synthesise the results.

[22] http://goteborg.se/wps/wcm/connect/171d705a-cfa7-48fe-b788-c0b18eac593e/OPA_R_BKAenglish.pdf?MOD=AJPERES, access date: 2014-11-29

As the redevelopment strategies were developed within the research project, the main interest in this workshop was on a conceptual level, not the detailed results of the different analyses. One of the reflections from the workshop was that qualitative and semi-quantitative methods seem more relevant in this stage (development of detailed plan). Monetisation of costs and benefits items with help of CBA in the SCORE analysis was perceived by workshop participants, in particular planners, as risky, because available data with regard to redevelopment is limited and highly uncertain in the early planning phase. On the other hand, the structured comparison of alternatives was seen as potentially very useful, as this was not a common way of analysing different aspects in every day planning practice at the Urban Planning Office. Usually, negotiations with stakeholders in the detailed planning process lead to elaboration of only one redevelopment strategy. In Table 4-6, results from a questionnaire are presented. There were only questions related to SCORE and to the mapping of eco-system services, no questions related to the social impact analysis, since this was a tool already known by the participants. Short reflections by the participants are also presented in Table 4-6.

Table 4-6. Answers to the questionnaire on the stakeholder workshop 2.

QUESTION	**RESPONDENTS**	**DEGREE OF AGREEMENT** Not at all					To a very high degree	
1. Did you receive any *new* information about the Fixfabriken site that is helpful in your continuing work?	Stakeholders (3 persons)			II 67%			I 33%	
	Other participants (2 persons)					I 50%	I 50%	
2. Is SCORE an assessment you would like to use in other similar projects?	Stakeholders (3 persons)		I 33%	I 33%	I 33%			
	Other participants (2 persons)				I 50%		I 50%	
3. Would you recommend your colleagues to work with SCORE?	Stakeholders (3 persons)		II 67%		I 33%			
	Other participants (2 persons)					I 50%	I 50%	
4. Is ESS mapping an assessment you would like to use in other similar projects?	Stakeholders (3 persons)					I 33%	II 67%	
	Other participants (2 persons)						II 100%	
5. Would you recommend your colleagues to work with ESS mapping?	Stakeholders (3 persons)					I 33%	II 67%	
	Other participants (2 persons)					I 50%	I 50%	

Table 4-6. Continued

QUESTIONS	RESPONDENTS	ANSWERS
6. Short reflections:	Stakeholders (3 persons)	"Complexity vs benefit to use SCORE in projects for waste and water management. Mapping of ESS seems to give a good overview. Positive to consider subsurface issues." "SCORE seems difficult to apply in the work with waste and water management, but ESS mapping seems very relevant. I miss an analysis of how to consider pipes in early phases, especially for gravity pipes." "Interesting new knowledge. I don't believe that we at the planning department can work with SCORE but very good to know about in order to be able to hire someone (consultant) that can consider these issue in early stages of similar projects. Good knowledge in many of the areas of the central parts of the city that will be in focus in the coming years."
	Other participants (2 persons)	"I think the analysis models are good but I think it is relevant to consider in a scheme together with other important aspects. The "clear" results that these models give should be balanced with similarly clear messages about knowledge gaps."

In addition to the responses to the questionnaire, written reflections were given by one of the stakeholders, the responsible project manager at the Urban Planning department. In the following a short summary (free translation) of these reflections is presented.

> A lesson learned is to make use of a number of scenarios before negotiating between interests. The negotiating process between different interests is something we as planners do as a part of our expertise, but clearly structuring scenarios and assess and compare those from different points of view could strengthen the communication about what we do. To dare to do this even if the data availability is not complete.
>
> But to find a manageable way to do this. SCORE has a too heavy part on costs in this early phase – it demands a lot of work and is uncertain. Could it be done with e.g. smileys instead, or +/- signs?
>
> But maybe the secret is to do these assessments/matrices early, to support the choice of a certain pathway forward by clearly showing differences.
>
> One reflection is that the Social Impact Analysis got so much stronger as a comparative than descriptive tool.
>
> About ESS mapping, I have a problem with this because of the focus on services for humans. There is already a method for supporting compensational measures for environmental values developed by the municipality which is used as a basis for discussion with relevant departments. It is meaningful as it builds upon a dialogue about values and measures. But maybe eco-system services is the tool we wanted, to

transfer soft values into hard fact to make them be taken more seriously.
I feel sorry that it is needed.

4.5 Synthesis

Table 4-7 presents the ranking of the different alternatives according to the three different analyses: SCORE, mapping of ESS and SIA. It should be noted that although the focus is different of the three analyses, there is some overlapping. For example, in all analyses, the cultural heritage is taken into account. Some social aspects may be overlapping between SIA and SCORE, although in SCORE, both the implementation of the remediation as well as the final result is taken into account whereas in SIA focus is on the final result of the implemented plan and with a broader view than that of SCORE.

Table 4-7. Ranking of alternatives according to the different sustainability analyses.

ALTERNATIVE	RANK ACCORDING TO SCORE	RANK ACCORDING TO MAPPING OF ESS	RANK ACCORDING TO SIA
Alternative 1	4	4	4
Alternative 2	3	1	3
Alternative 3	1	2	2
Alternative 4	5	5	5
Alternative 5	2	3	1

4.6 Discussion

The data availability is very low at Fixfabriken as it is still in an early redevelopment phase. As a consequence, all calculations in SCORE have a relatively high degree of uncertainty and it may be questionable if the SCORE method is suitable for such an early phase. Uncertainties are explicitly treated on the other hand, which allows the assessor to find out what type of information is crucial to improve the assessment. The CBA analysis (Garção, 2015) in SCORE and the full SCORE analysis show that although data is limited it is possible to make rather extensive analyses. It should be noted however, that potential damages on surrounding buildings due to soil settlements were not considered in CBA.

A practical issue is (as always) who is willing to pay for the assessments in very early stages as it do require some efforts. A practical challenge of rather detailed analyses in phases where data availability is low is how to communicate results which contain high levels of uncertainty to stakeholders. Although there are some challenges with quantitative analyses like SCORE, semi-quantitative analyses and qualitative analyses seem to be applicable and useful in early stages. A structured comparison may reveal important information to planners to include in the development of a plan.

Alternatives 1 and 3 are equal from a detail plan point of view, although the remediation strategies differ and the SCORE assessment results are accordingly different. As the actual implementation of a plan is not regulated in the plan itself, this means that what

must be taken into account in early stages of the redevelopment, is to ensure that the path forward is not fixed towards unsustainable solutions. Thus, although the implementation of the plan cannot be regulated, it should be considered in the plan. This also means that there may be a challenge to transfer achieved knowledge from one (re)development phase to the following when the regulatory systems (and actors) changes.

In this case study, we applied the hypothesis that cheaper remediation allows for cheaper housing, and thus a larger mix of housing price levels. However, this is not necessarily true, as it will depend on the private developer and if the municipality explicitly demands a proportion of cheaper housing. However, although the results of the SIA may be somewhat shaky, SIA used in this comparative way was seen as effective. Potentially, it can be a way to explore the connection between subsurface issues and surface social impacts. In Alternatives 3 and 5, the costs for the remediation affect the uncertainty of the SCORE results, especially for Alternative 3.

A point of departure for the practical application of SCORE is that all remediation strategies are acceptable from a risk point of view. However, some options assuming in-situ treatment included in the Balance 4P analyses are not widely accepted in Sweden today. Alternative 5 assumes the highest degree of preserving old buildings and archaeological remains and gains high ranking due to this in both the SCORE analysis as well as the SIA. The exact location of remains are however still uncertain.

The mapping of ESS yields a slightly different ranking of the remediation strategies compared to the SCORE and SIA assessments. In the ESS analysis, alternative 2 stands out as the most favourable strategy. This outcome is mainly explained by positive effects on the supply of ecosystem services accruing to the creation of a green space in connection to the Fixfabriken remediation area. In addition, this alternative avoids negative impact on existing green space in the area adjacent to the Fixfabriken, an area which is negatively affected in other remediation strategies. A general conclusion from the ESS mapping analysis is that negative effects on the supply of ecosystem services that result from deposition of polluted soil at off-site landfills play an important role for the final ranking of alternatives when it is included in the analysis.

All in all, the focus of the Balance 4P project proved to be relevant: procedures differs greatly between sectors and may contribute to revive each other. It was also found that when combining the view of the two sectors, the system becomes very complex and it is difficult to encompass all aspects of brownfield redevelopment in a single tool: i.e. working with complementary tools was found relevant. Finally, direct communication in workshops proved to be an efficient way to knowledge exchange between actors.

4.7 Advice for Fixfabriken case

The advices that can be offered to the Fixfabriken area are summarized below.

From the SEES workshop:

- Investigate the archaeological remains prior to deciding on the plan to map how valuable the remains are and if there will be a conflict with remediation and construction;

- Consider groundwater levels and infiltration of water. A hydrogeological investigation of the site is recommended. Permeable sidewalks etc. to allow for locally infiltrating precipitation can be important elements in the urban design;
- The contamination situation should be mapped, preferably prior to decision on plan, to potentially locate residential areas in parts less contaminated.

From the sustainability assessments:

- Minimise excavation and transports from the site;
- Explore alternative remediation strategies together with controlling authorities to gain acceptance;
- In the assessment of different remediation alternatives, explore and include potentially negative effects on the supply of ecosystem services from depositing polluted soil at off-site landfills;
- Identifying models for mixing cheaper housing with more expensive will have positive social effects;
- Explore possibilities to preserve the Fixfabriken factory.

4.8 The proposed plan for the Fixfabriken area

For Fixfabriken, the proposed plan[23] by the Urban Planning Department in April 2015 can be considered to be in accordance with one of the least preferred alternatives (Alt 1) in the assessment carried out within the research project.

Reasons for this divergence in results are primarily because of the politically highly prioritised objective to, as fast as possible, deliver more housing in Gothenburg. In real life, this objective overruled the other objectives which were considered in the assessments in the research project. Moreover, the research project had an explorative intention and the assessments did, therefore, not fully consider some of the boundary conditions of the real case, e.g. the fact that the private developers would not be willing to invest money in remediating a site if the revenues by being able to sell housing in a later stage were uncertain or delayed, especially since the revenue level had already been informally guaranteed by the municipality. However, the knowledge gained from the workshops and the students' work was still used by the municipality and incorporated in the in-depth description[24] of the basis for the detailed plan proposal submitted for public considerations during the period April to August 2015. It cannot be stated that the work in the research project was effective in supporting the decisions taken by the municipality, but it did, however, provide insights of more qualitative character for the individual officials involved in developing the plan proposal.

[23] http://www5.goteborg.se/prod/fastighetskontoret/etjanst/planobygg.nsf/vyFiler/Majorna%20-%20Program%20f%C3%B6r%20Fixfabrikomr%C3%A5det-Program%20-%20samr%C3%A5d-Program/$File/Program.pdf?OpenElement (Access date 2015-06-30) *In Swedish*

[24] http://www5.goteborg.se/prod/fastighetskontoret/etjanst/planobygg.nsf/vyFiler/Majorna%20-%20Program%20f%C3%B6r%20Fixfabrikomr%C3%A5det-Program%20-%20samr%C3%A5d-Underlag%20f%C3%B6rdjupning%20del%201-3/$File/Underlag_fordjupning1-3.pdf?OpenElement (Access date 2015-06-30) *In Swedish.*

5 On-line stakeholder webinar

An on-line international stakeholder workshop with 22 participants was carried out on November 12th, 2014. Attendants at the webinar included project partners (11 persons) and case holders (7), the SNOWMAN community at a European level (3 persons), and an external researcher. The workshop had the purpose of presenting the interim outcomes of the project to the stakeholders and of identifying and discussing common grounds between case studies (shared problems, knowledge gaps and solutions used to deal with those difficulties). The objective of the workshop was also to make stakeholders become ambassadors of the project results, to get feedback on the work in the different cases (and possibly on the holistic approach as well), and the case-holders to learn from each other.

The agenda of the workshop included a brief description of the project and of the case studies, followed by reflections by the case holders of each site. Additionally, an overview of the proposed holistic approach and a generic decision process framework was presented and discussed with the participants (not discussed here).

At the end of the workshop, the participants were asked to answer an on-line survey, of which we received answers from a total of 10 respondents. The survey was created on "Surveymonkey" and the link was distributed via the chat and via e-mail by the end of the workshop. Ten respondents filled out the questionnaire completely or partly, of those, 4 specified that they were from the subsurface sector, and 2 from the surface sector (4 did not specify this). There were 3 respondents who specified they were from Sweden, 1 from Belgium and 2 from the Netherlands (4 did not specify this). Below, a more detailed summary of the responses relating to the work in the case studies. The respondents found several of the different tools and methods presented useful.

Q7. Did you gain any valuable information from the presented case studies?

Here, several replied yes, and stated e.g. that it is possible to implement in one owns project, that it is applicable to different kinds of cases, and that a lot of valuable information was presented. Some replied partly, one mentioned that the Alvat site was interesting and easy to follow, another that the social impact analysis was interesting and that it was nice to see that others had applied the SEES method.

Q8. Which of the mentioned methods and tools (e.g. Stakeholder analysis (SA), SEES, ESS-mapping and valuation, Sustainability assessments of remediation (MCA-tools), Social impact assessment (SIA)) do you believe could be applicable and beneficial in integrating subsurface aspects into the planning process?

The following were given by respondents: The combination of them; SA + SEES + SIA; SEES + MCA-tools + SIA; SA + SEES + ESS-mapping and valuation + SIA + add U-scan (underground scan); SA + SEES + Brownfield tools (BR2tool, Brownfield navigator, Brownfield Opportunity Matrix) + ESS-mapping and valuation + MCA-tools; SA.

6 Discussion and main lessons learned

This report presents the work carried out within three case studies, in three different countries, each with their own regulatory setting, and for each case different researchers and stakeholders have been involved. With regard to being able to generalise the results this may be a weakness, however, the learning and experiences from the three cases must still be regarded as valuable and some common grounds are identified. Even if the researchers in the three cases had their own point of departure (different background and expertise) there was a joint vision on what to explore in the three cases.

Funding and organisation made the prerequisites differ for the cases, especially with regard to involvement of the municipalities and the actual implementation of the results. For the Merwevierhavens case, the municipality funded large parts of the work and had a self-interest in where the process was heading and how to make the result useful. For the Fixfabriken case, the municipality had an interest to co-explore the possibilities of greater incorporation of contamination and remediation issues (expanded to subsurface issues during the course of the project) earlier into the planning phase. In the Alvat case, the driving force behind choosing the Alvat site was OVAM (also one of the funding organisations of the research project), who had an interest in the cleaning up and the redevelopment of the site. Thus, the municipality in Buggenhout were not initiators and retrospective, it is possible that the involvement and the feedback had been different if the municipality had been the driving force, and had the site not been a “black field” in a more rural setting with a very high uncertainty about the future of the site.

Something that was not explicitly done in any of the cases was to try to synthesise the results of various sustainability assessment together with stakeholders. However, the summarized results can form the basis for discussions among stakeholders and thus act as a basis for a transparent decision.

In the following, the main lessons learned from the cases are listed.

- The SEES methodology provided important insights to planners. In the Merwevierhavens case, two SEES workshops proved effective to get more into details on subsurface inclusion in the planning process. The first workshop can be used to sort out the subsurface aspects relevant to the study area. The second one can be used to refine information from the first workshop focusing on the identified subsurface qualities;

- It is clear from the Merwevierhavens and the Fixfabriken case studies that there is a lot of subsurface information available (e.g. archaeology, geology, and hydrogeology), but it is not systematically treated in the planning process due to established planning culture. On the other hand, information on soil and groundwater contamination can be very limited in the early redevelopment phases;

- Student involvement can be an effective instrument for generating urban design ideas and innovative solutions for subsurface inclusion in the early redevelopment phases. This method proved to work well in the all three case studies;

- Direct communication is more efficient than documents, but expert knowledge must be delivered in the right form at the right moment. It is important to take time to prepare subsurface information in an approachable form. For example in the Fixfabriken case, had the project been even more sharp, more people would have attended and had more time to prepare;

- It's important to have all subsurface information from municipality and private companies. The lesson learned from the Merwevierhavens case was that there is a need for new procedures for transferring subsurface information (in particular, on cables and pipes) when property ownership passes from private to public owners and vice versa;

- A structured approach for generating and assessing (urban redevelopment) alternatives can strengthen the work of urban planners;

- Challenges of bringing in detailed quantitative analyses into early redevelopment phases are related to communication and use of results, as well as data availability. Instead qualitative (or semi-quantitative) analyses seems very applicable in early phases of the redevelopment process;

- Redevelopment of brownfields deals with complex systems. All aspects cannot be covered in one type of analysis. Combination of instruments is demanded to complement sustainability assessments;

- The methods for subsurface inclusion and sustainability assessments can face limited interest of the stakeholders and planners in the initiative and plan phases due to the complexity of urban redevelopment projects, high degrees of uncertainty in the assessment results, and insufficient support in policy, law and regulation;

- There must be someone owning/responsible for the process to incorporate subsurface into the planning procedures - otherwise it may seem useless to stakeholders. This was especially a challenge in the Alvat case, where the municipality responsible for the development of a plan, was not explicitly involved in the case study work.

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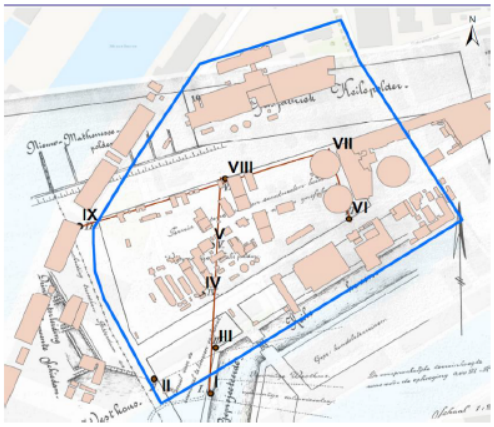
8 Appendix A: Rotterdam Merwevierhavens idea book

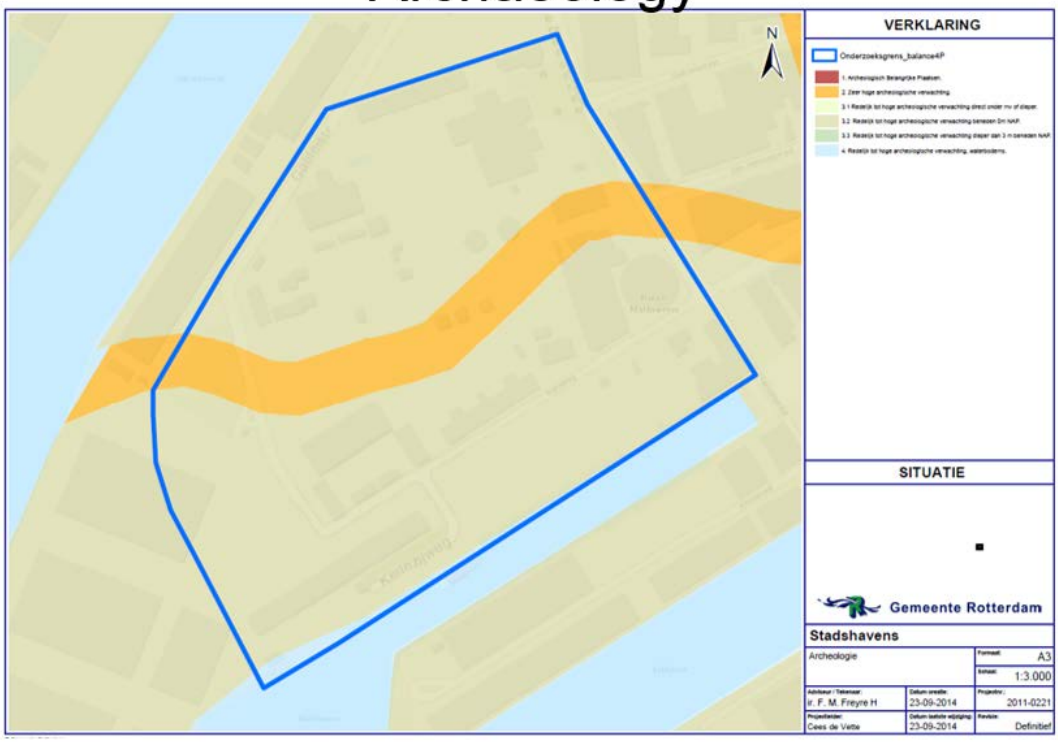
Idea book EON/Eneco/Ferro Merwevierhavens, Rotterdam

Here the analyses, the steps of bringing knowledge together and the final ideas that came up in the workshop of 23 sept'14 are represented.

Example projects are tagged with categories that they contribute to .



Archaeology



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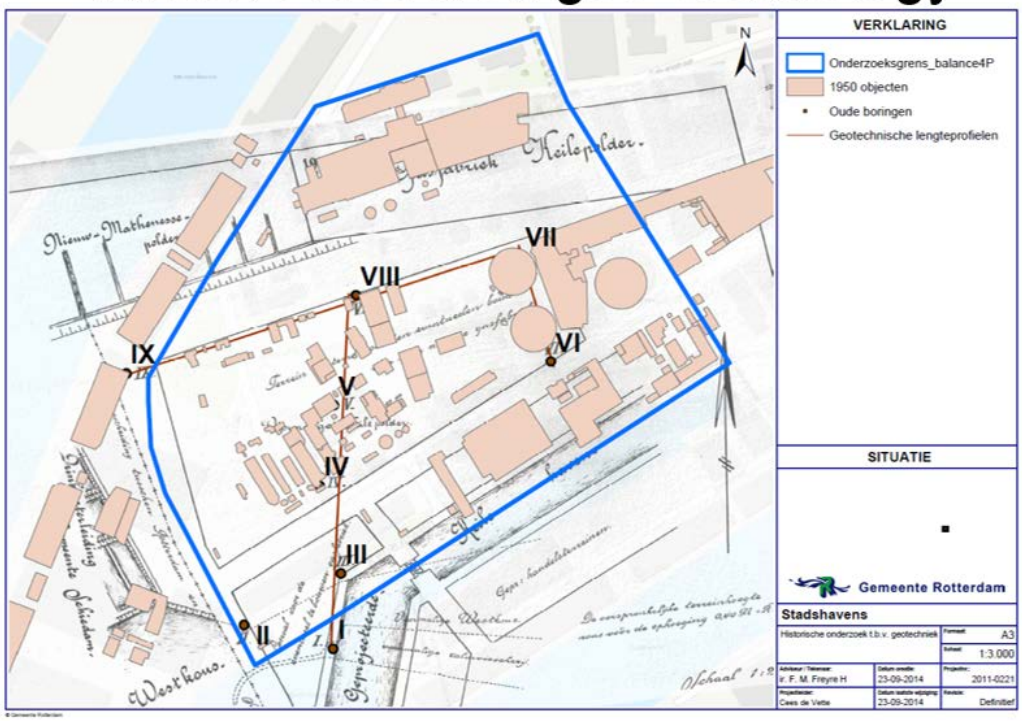
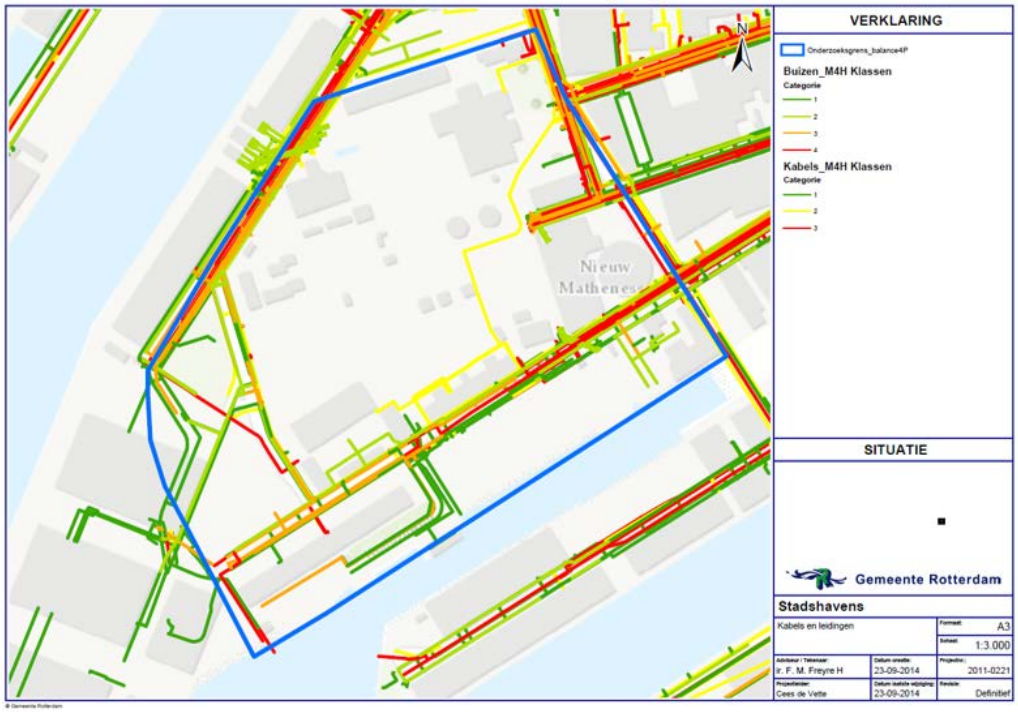
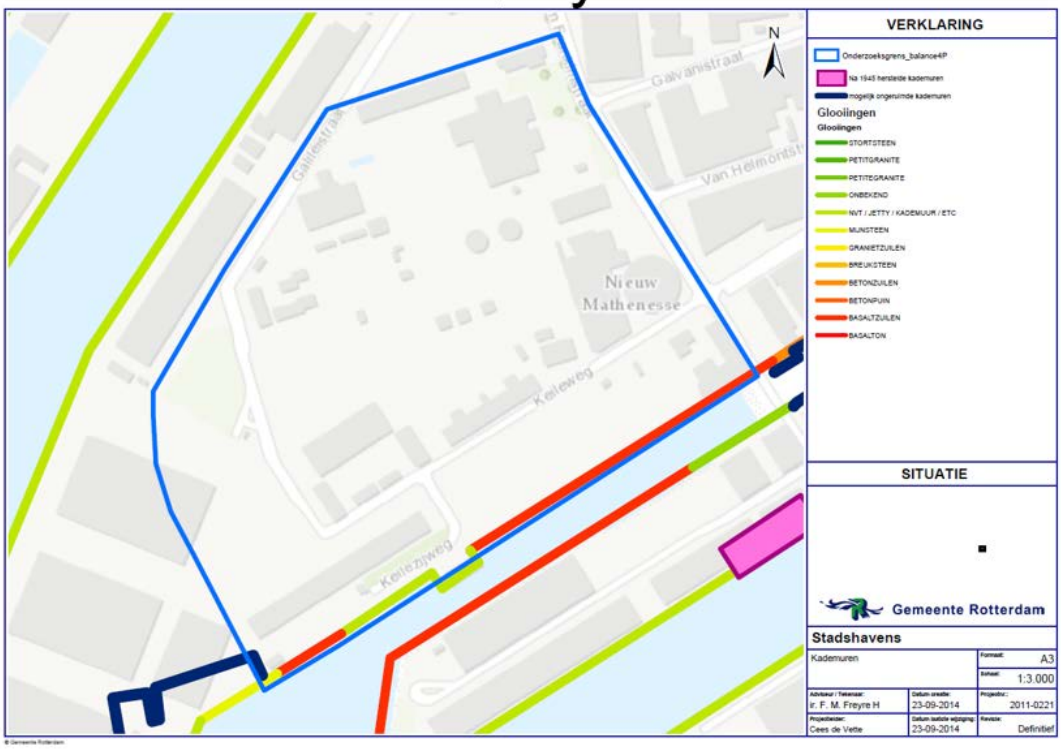
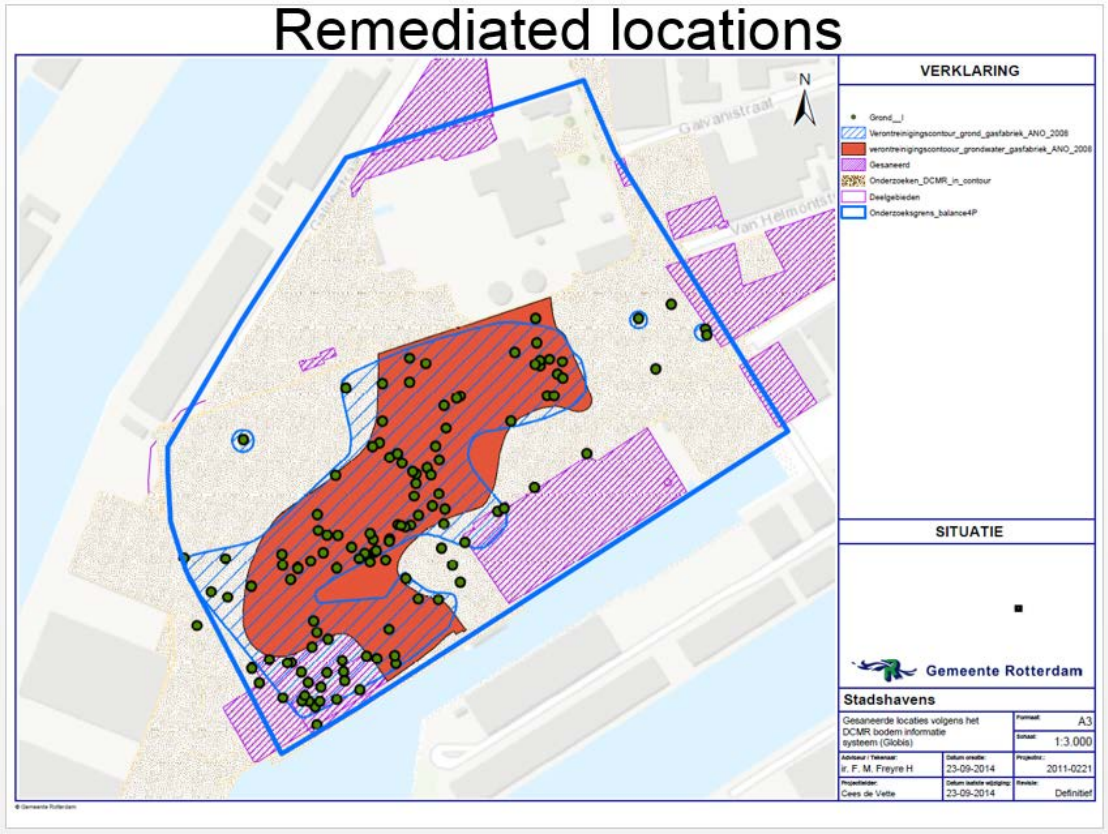


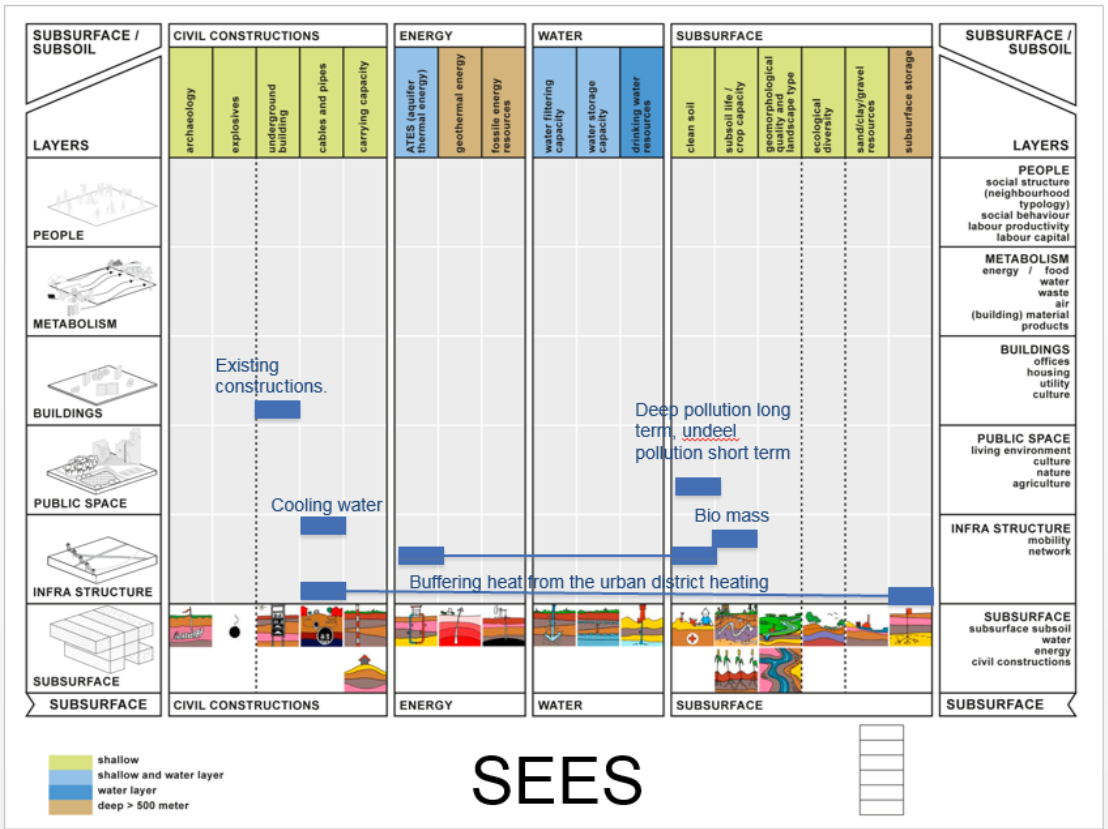
Cables and pipes

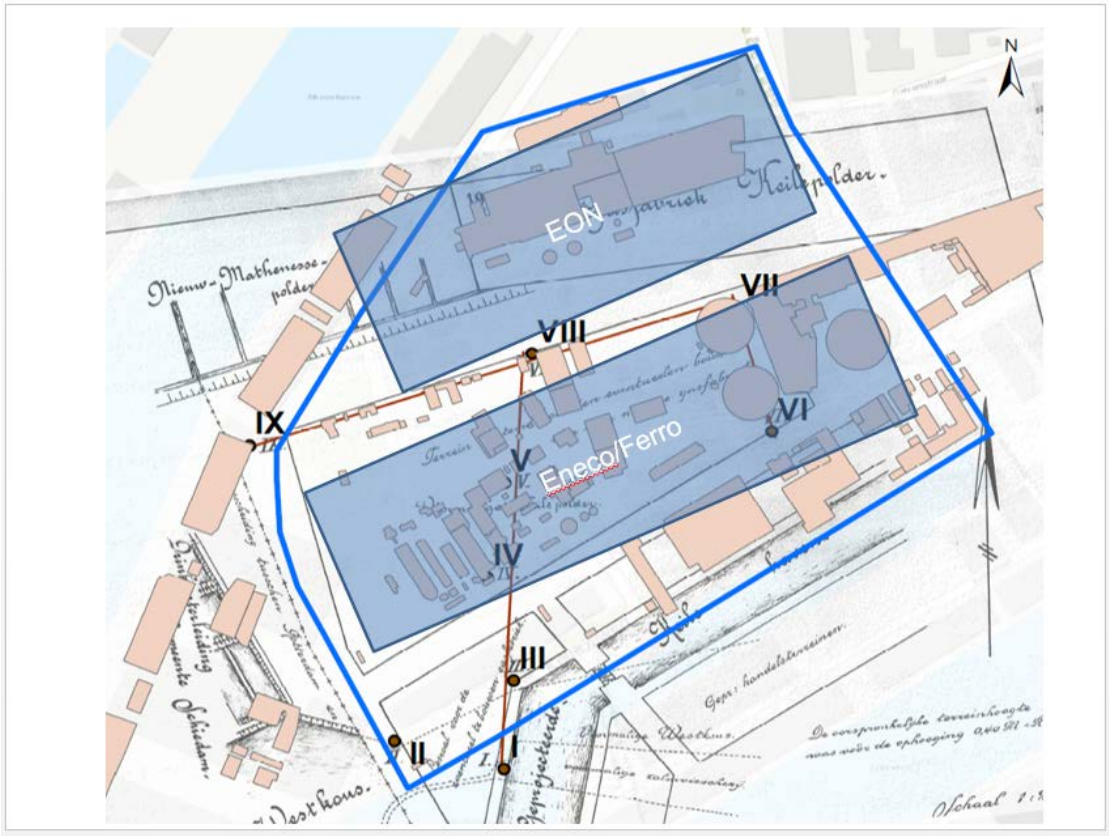


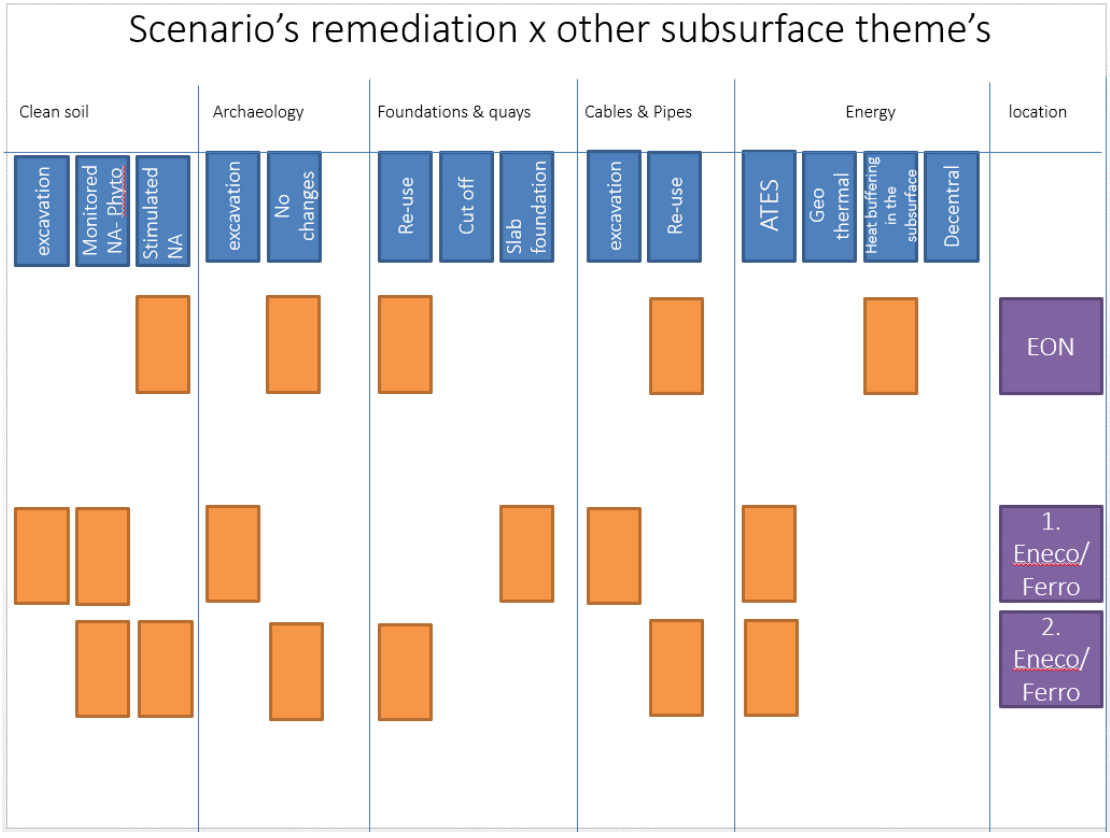
Quays




Remediated locations
VERKLARING
SITUATIE
Gemeente Rotterdam
Stadshavens
Gesaneerde locaties volgens het DCMR bodem informatie systeem (Globis)
A3
1:3.000
ir. F. M. Freyre H
23-09-2014
2011-0221
Cees de Vette
23-09-2014
Definitief

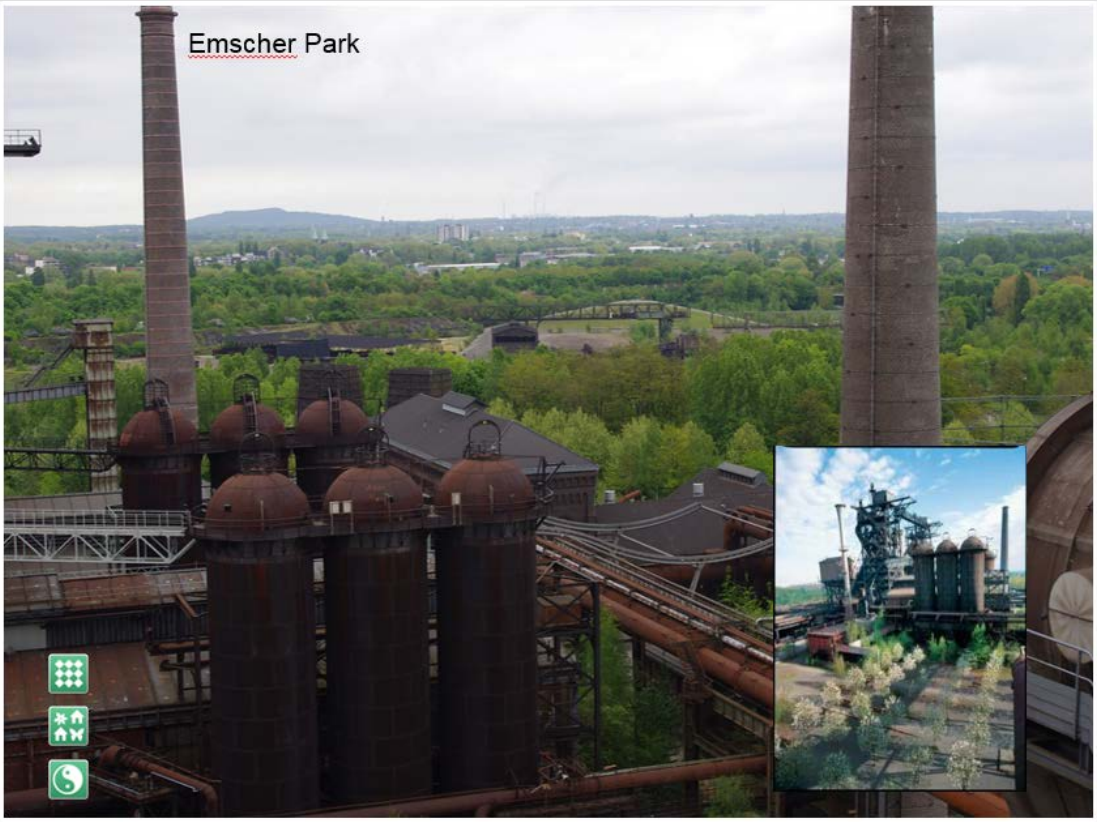

SUBSURFACE / SUBSOIL
LAYERS
CIVIL CONSTRUCTIONS
archaeology
explosives
underground building
cables and pipes
carrying capacity
ENERGY
ATES (aquifer thermal energy)
geothermal energy
fossile energy resources
WATER
water filtering capacity
water storage capacity
drinking water resources
SUBSURFACE
clean soil
subsoil life / crop capacity
geomorphological quality and landscape type
ecological diversity
sand/clay/gravel resources
subsurface storage
PEOPLE
METABOLISM
BUILDINGS
PUBLIC SPACE
INFRA STRUCTURE
SUBSURFACE
Existing constructions.
Cooling water
Deep pollution long term, undeel pollution short term
Bio mass
Buffering heat from the urban district heating
PEOPLE social structure (neighbourhood typology) social behaviour labour productivity labour capital
METABOLISM energy / food water waste air (building) material products
BUILDINGS offices housing utility culture
PUBLIC SPACE living environment culture nature agriculture
INFRA STRUCTURE mobility network
SUBSURFACE subsurface subsoil water energy civil constructions
shallow
shallow and water layer
water layer
deep > 500 meter
SEES

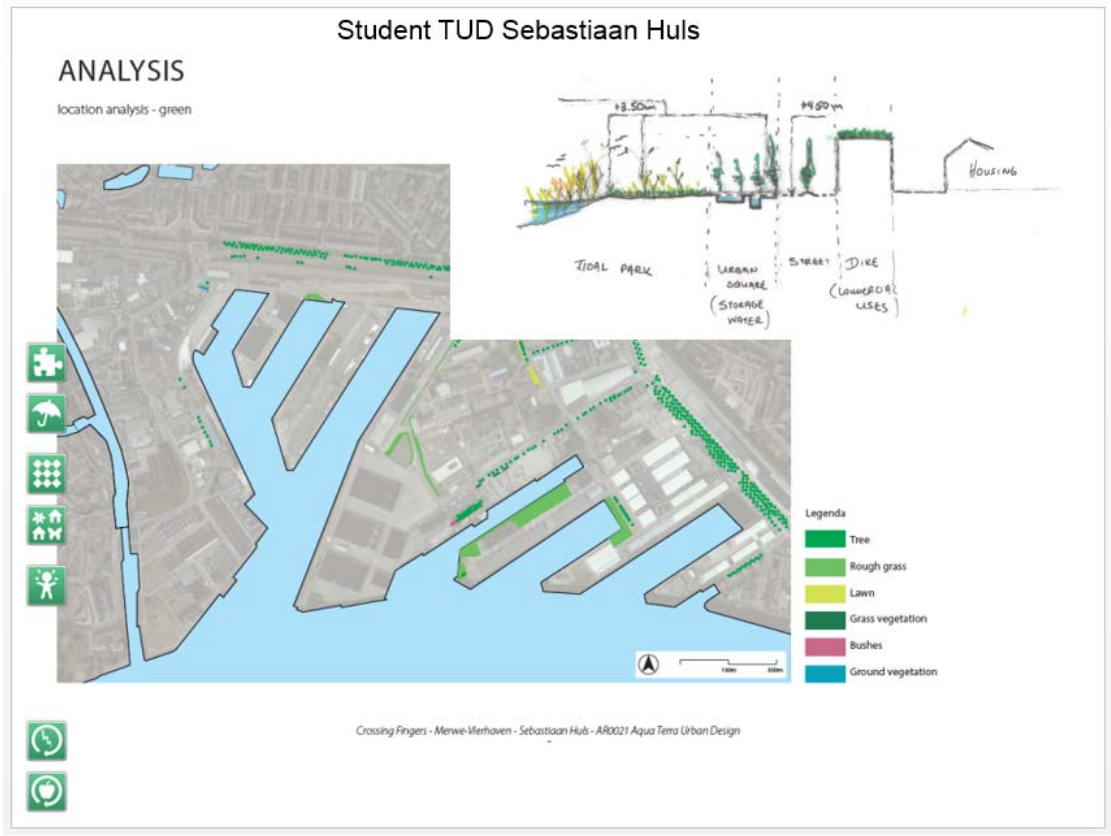

N
EON
Eneco/Ferro
VII
VIII
IX
VI
V
IV
III
II
I


Scenario's remediation x other subsurface theme's
Clean soil
Archaeology
Foundations & quays
Cables & Pipes
Energy
location
excavation
Monitored NA- Phyto
Stimulated NA
excavation
No changes
Re-use
Cut off
Slab foundation
excavation
Re-use
ATES
Geo thermal
Heat buffering in the subsurface
Decentral
EON
1. Eneco/ Ferro
2. Eneco/ Ferro

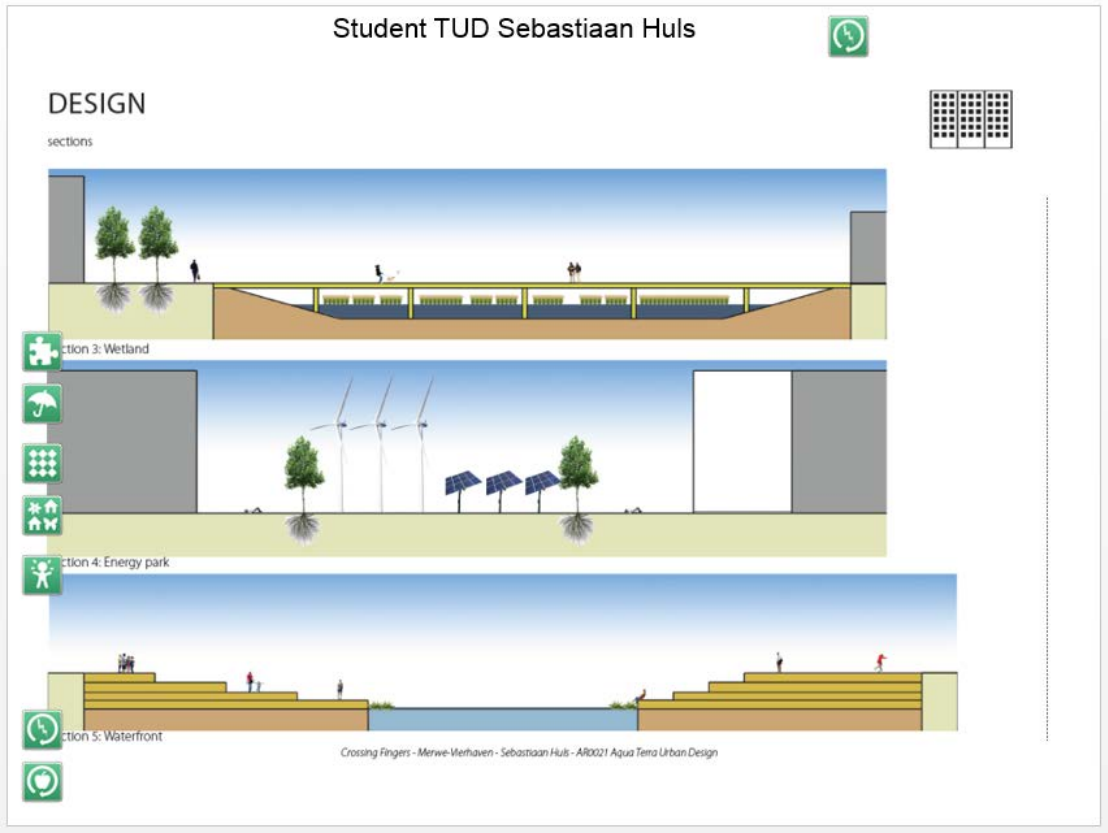
Categories

- Connectivity
- Climate change
- Efficient use of space
- Green cities
- Health and liveability
- Resource efficiency
- Strong and resilient society
- Sustainable energy
- Sustainable food production




Student TUD Sebastiaan Huls
ANALYSIS
location analysis - green
+8.50m
+9.50m
HOUSING
TIDAL PARK
URBAN SQUARE
(STORAGE WATER)
STREET
DIKE
(COMMERCIAL USES)
Legenda
Tree
Rough grass
Lawn
Grass vegetation
Bushes
Ground vegetation
Crossing Fingers - Merwe-Vierhaven - Sebastiaan Huls - AR0021 Aqua Terra Urban Design


Student TUD Sebastiaan Huls


Student TUD Sebastiaan Huls
DESIGN
sections
ction 3: Wetland
ction 4: Energy park
ction 5: Waterfront
Crossing Fingers - Merwe-Vierhaven - Sebastiaan Huls - AR0021 Aqua Terra Urban Design

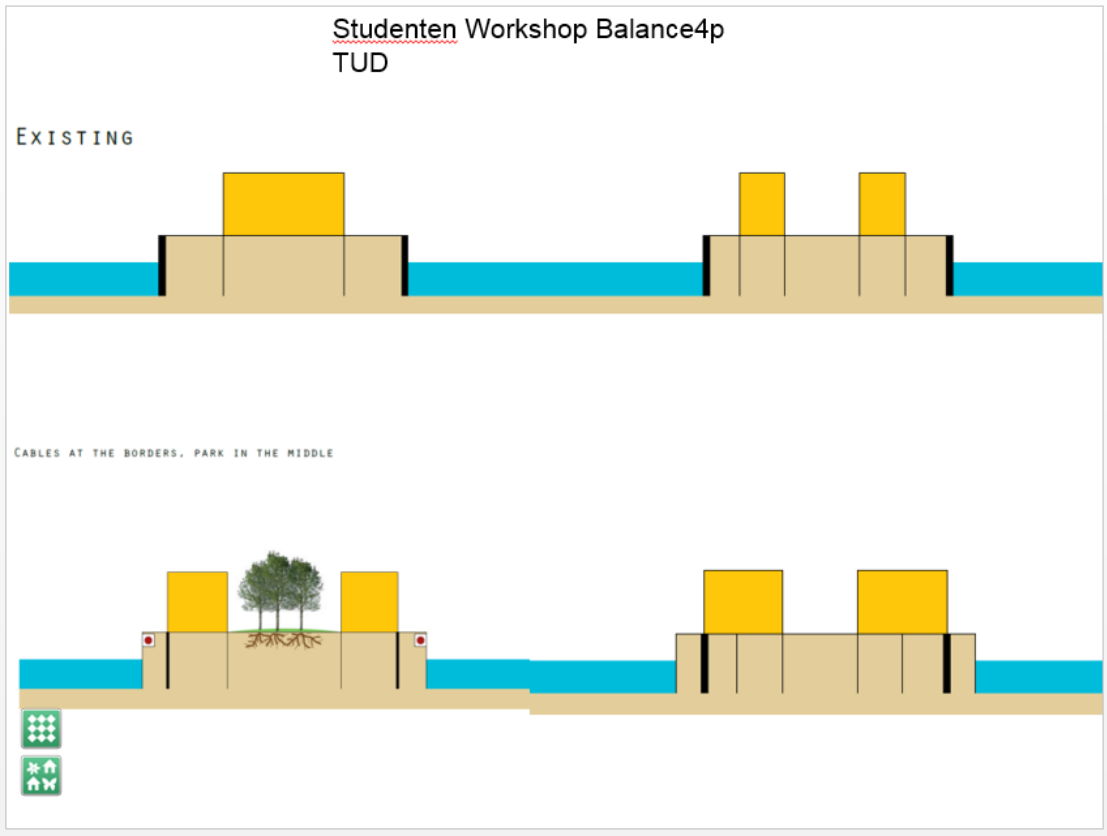

DoepelStrijkers Architecten
oplaadstation voor elektrische auto


GRONDSANERING GASFABRIEK
DoepelStrijkers Architecten

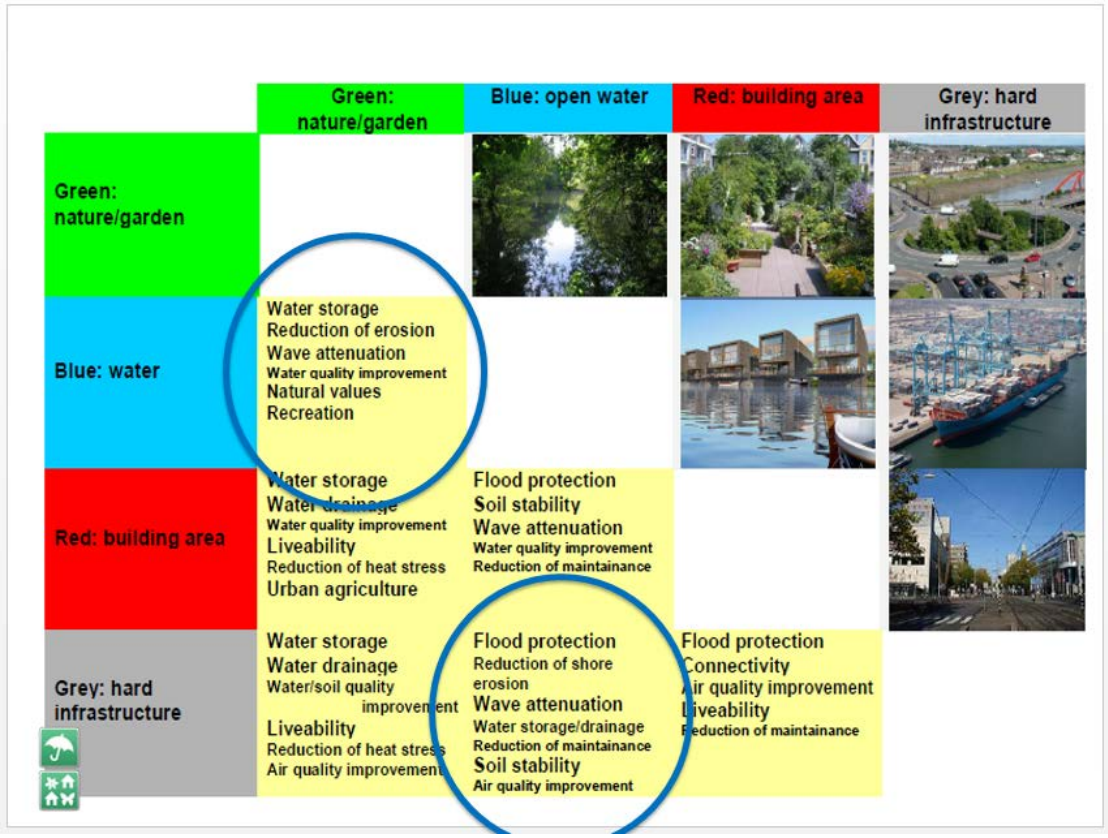

DoepelStrijkers Architecten
FLEXIBELE WONINGEN VOOR EARLY ADOPTERS

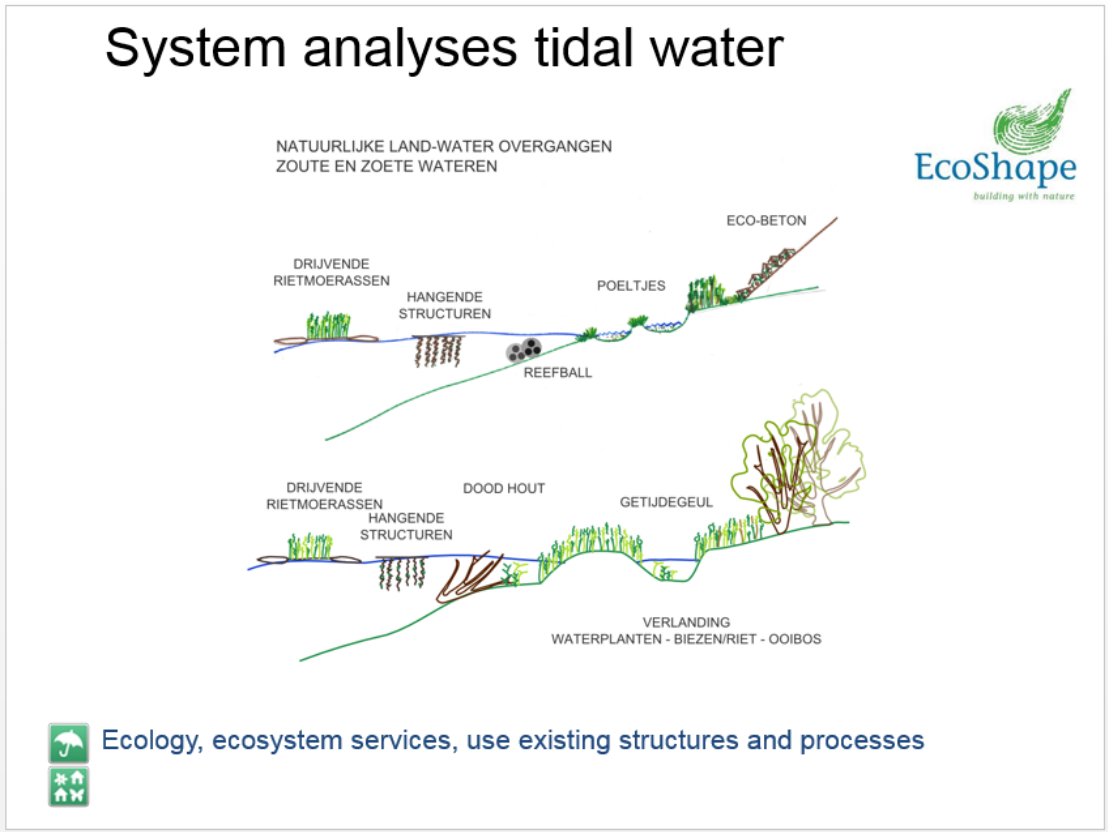

DoepelStrijkers Architecten


De Ceuvel Amsterdam


Studenten Workshop Balance4p
TUD
EXISTING
CABLES AT THE BORDERS, PARK IN THE MIDDLE


DoepelStrijkers Architecten


Green: nature/garden
Blue: open water
Red: building area
Grey: hard infrastructure
Green: nature/garden
Blue: water
Red: building area
Grey: hard infrastructure
Water storage
Reduction of erosion
Wave attenuation
Water quality improvement
Natural values
Recreation
Water storage
Water drainage
Water quality improvement
Liveability
Reduction of heat stress
Urban agriculture
Flood protection
Soil stability
Wave attenuation
Water quality improvement
Reduction of maintainance
Water storage
Water drainage
Water/soil quality improvement
Liveability
Reduction of heat stress
Air quality improvement
Flood protection
Reduction of shore erosion
Wave attenuation
Water storage/drainage
Reduction of maintainance
Soil stability
Air quality improvement
Flood protection
Connectivity
Air quality improvement
Liveability
Reduction of maintainance


System analyses tidal water
NATUURLIJKE LAND-WATER OVERGANGEN
ZOUTE EN ZOETE WATEREN
EcoShape
building with nature
ECO-BETON
DRIJVENDE RIETMOERASSEN
HANGENDE STRUCTUREN
POELTJES
REEFBALL
DRIJVENDE RIETMOERASSEN
HANGENDE STRUCTUREN
DOOD HOUT
GETIJDEGEUL
VERLANDING
WATERPLANTEN - BIEZEN/RIET - OOIBOS
Ecology, ecosystem services, use existing structures and processes

Floating and hanging weeds

Drijvende rietmoerassen, pilot Houtribsluizen Markermeer (Bron: Deltares)

EcoShape
building with nature

Gors van de Lickebaert

Vijfsluizerhaven


Sustainable Remediation Technology
Conceived in 2010, SISSR technology collects and harnesses renewable energy and redirects it back into the remediation process. All energy consumed is produced onsite by wind and solar power. Each renewable energy source has two functions:
Wind
1. To produce compressed air which is then injected into the soil to support the biodegradation process
2. To extract soil vapors generated from the biodegradation process
Solar
1. To generate electricity to run all the small pumps and electrical components
2. To produce warm water using a solar thermal collector system which is then circulated into the soil to increase subsurface temperatures by 7 to 12° C
When soil temperatures increase from 10°C to 20°C, it has a positive effect on the remediation process since it enhances desorption. Not only will bacteria activity increase, but the contaminants' solubility and volatilization will also increase. This results in the mobilization of the contaminants from the soil phase to the water phase, making the contaminants more readily available for microorganisms to
sume. All of these factors assist in an
lerated remediation cleanup time.
Energy storage facilities are not necessary with SISSR since the demand for energy and heat can always be directed towards the process. When compressed air is not produced due to wind deficiencies and heat is not generated due to solar restrictions, this lull in activity is not a problem. It is believed these temporary interruptions allow preferential pathways in the subsurface to be redistributed with bacteria making it easier for the bacteria to consume the contaminants once the system starts up again.
Prior to the installation of this system, wind and solar calculations will need to be completed to determine the renewable energy efficiency levels in the area.
Blueforest
ENVIRONMENTAL DEVELOPMENT
Sustainable-Phyto-pump-treatment
Recommended for:
Deep depth
Any size
Saturated zone
Biodegradable contaminants
Porous media
Extended treatment time
SISSR: Sustainable In Situ Soil Remediation


1
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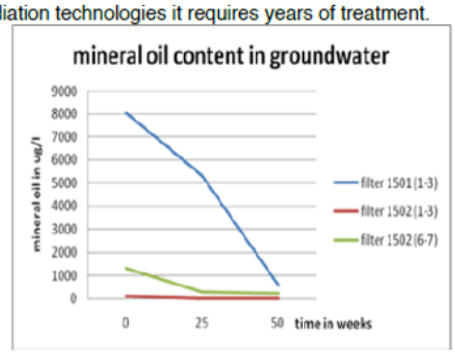
Blueforest
ENVIRONMENTAL DEVELOPMENT
SISSR: Sustainable In Situ Soil Remediation.
Each SISSR is built based on the conditions of the site but all contain the following pieces of equipment:
1. Solar collector- to heat the water
2. Solar cell- to generate electricity for the system
3. Solar invertor – to turn sunlight into energy
4. Turbine – to produce compressed air and extract vapors from the soil
5. Vent – to extract soil vapor
6. Compressor
7. Pressure vessel for air
8. Circulation pump 2
9. Boiler
10. Circulation pump 1
11. Nutrient injection pump
12. Nutrient storage
13. Vapor extraction
14. Groundwater level
15. Contamination area
16. Air injection
17. Soil heating elements
18. Nutrient injection

Case study in Bilthoven: Deltares en SBNS

The pilot study took place in Bilthoven, Netherlands on a site that has had a long history of industrial uses dating back to 1863. Rail line, warehousing, petroleum and coal distribution center, and a paint company were some of the operations that took place onsite. The site was contaminated with mineral oil ranging from a half meter to nine meters below the surface. In 2011, approximately two meters of the vadose zone was excavated leaving the remaining 7 meters of the saturated zone to be treated with SISSR. At the beginning of this study, soil temperature was 10° C. After 20 weeks of operation the soil temperature increased to 17.6 ° C and eventually reached 22° C. This increase in soil temperature accelerated the rate of contamination destruction. The goal of this system is to immobilize and to destroy contamination while preventing rebound effect with the least amount of cost. Since temperatures do not reach as high as thermal remediation technologies it requires years of treatment.



9 Appendix B: Fixfabriken - Social impact analysis

The social impact analysis tool (SIA) was developed as a tool to be used in urban planning in Gothenburg. It is typically used as an inventory tool to check what there is, what is needed and the anticipated impacts of the detailed plan. In the Balance 4P project, the SIA was used as a tool to investigate the social impacts with regard to each alternative. The SIA tool is displayed in the form of a matrix, which takes four different social aspects into consideration: Cohesive city, Interactions, Everyday life and Identity, see y-axis in Figure B-1. Those aspects are in line with the political objectives of the City of Gothenburg and are analysed with regard to five different scales: Buildings and places, Neighbourhood, District, City, and Region, see x-axis in Figure B-1.

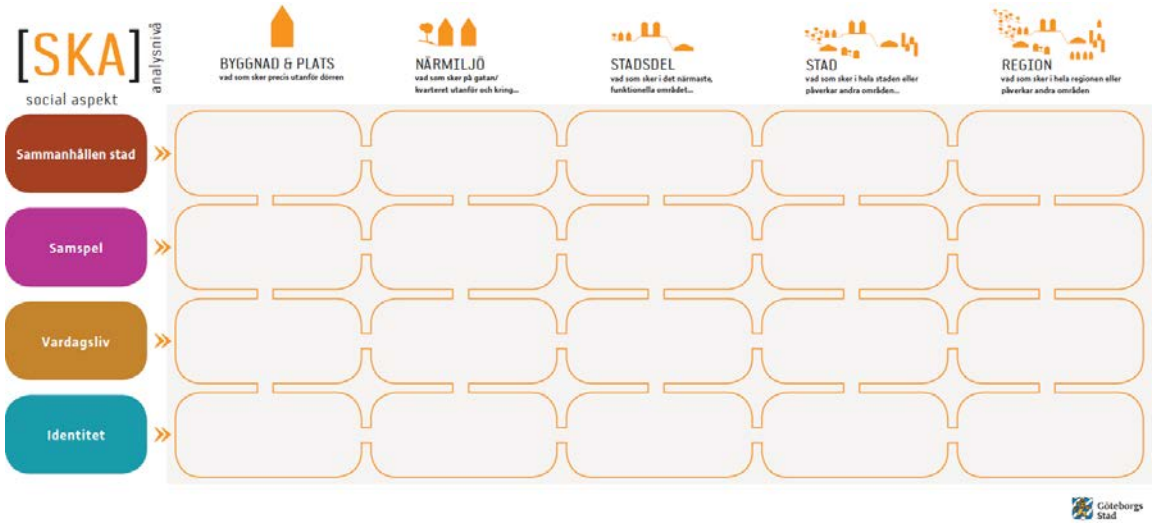


Figure B-1. The SIA tool matrix.

Focus in Balance 4P has been on Neighbourhood and District, since the conceptual redevelopment strategies are not detailed enough to provide information for an analysis on the scale of Buildings and places. The matrix was used to: 1) map the reference alternative, 2) map preferred changes, and 3) map the impacts on Alternatives 1 to 5. Figures B-2 to B-8 shows all matrices. The impacts are qualitatively valued on the following scale: very negative impacts: (--), negative impacts (-), no impacts (0), positive impacts (+), very positive impacts (++).

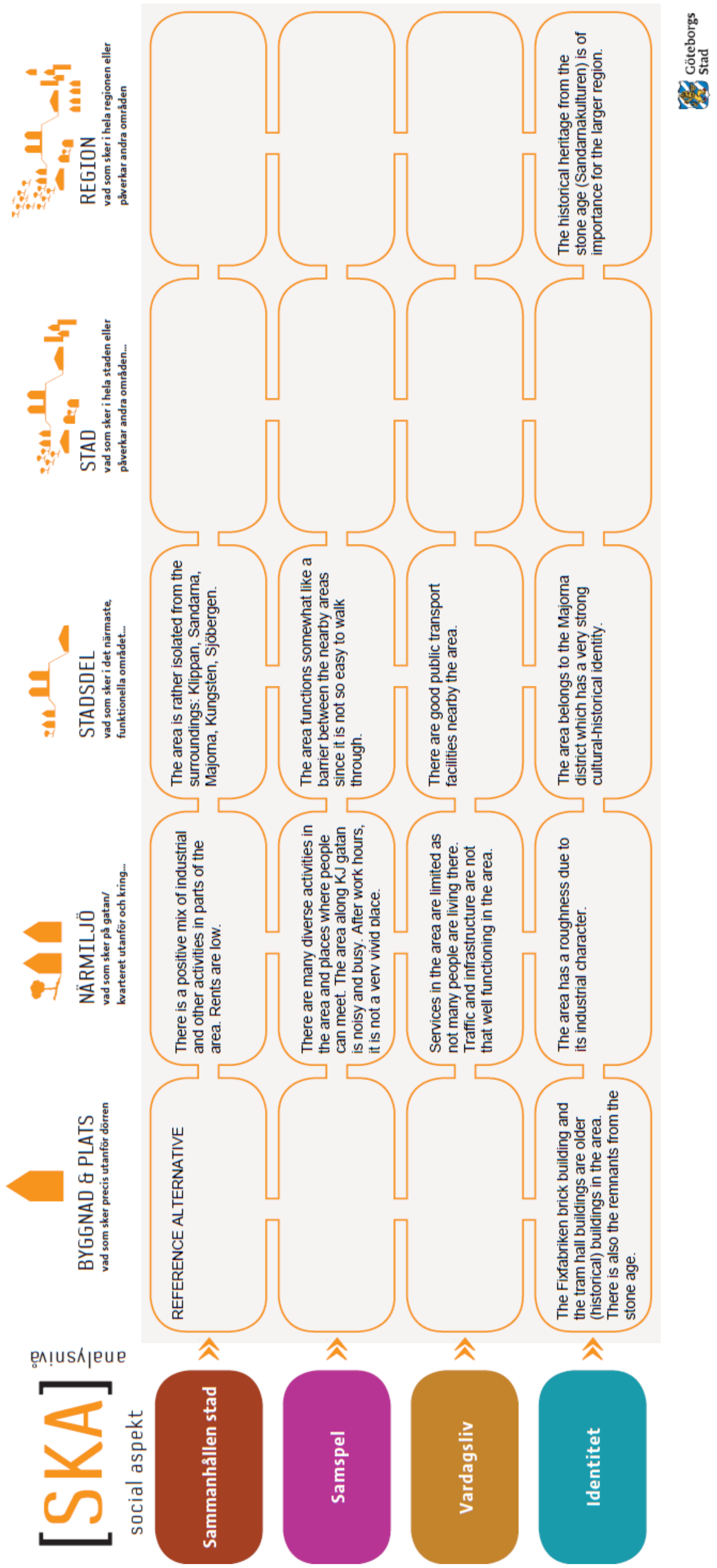


Figure B-2. The reference alternative.

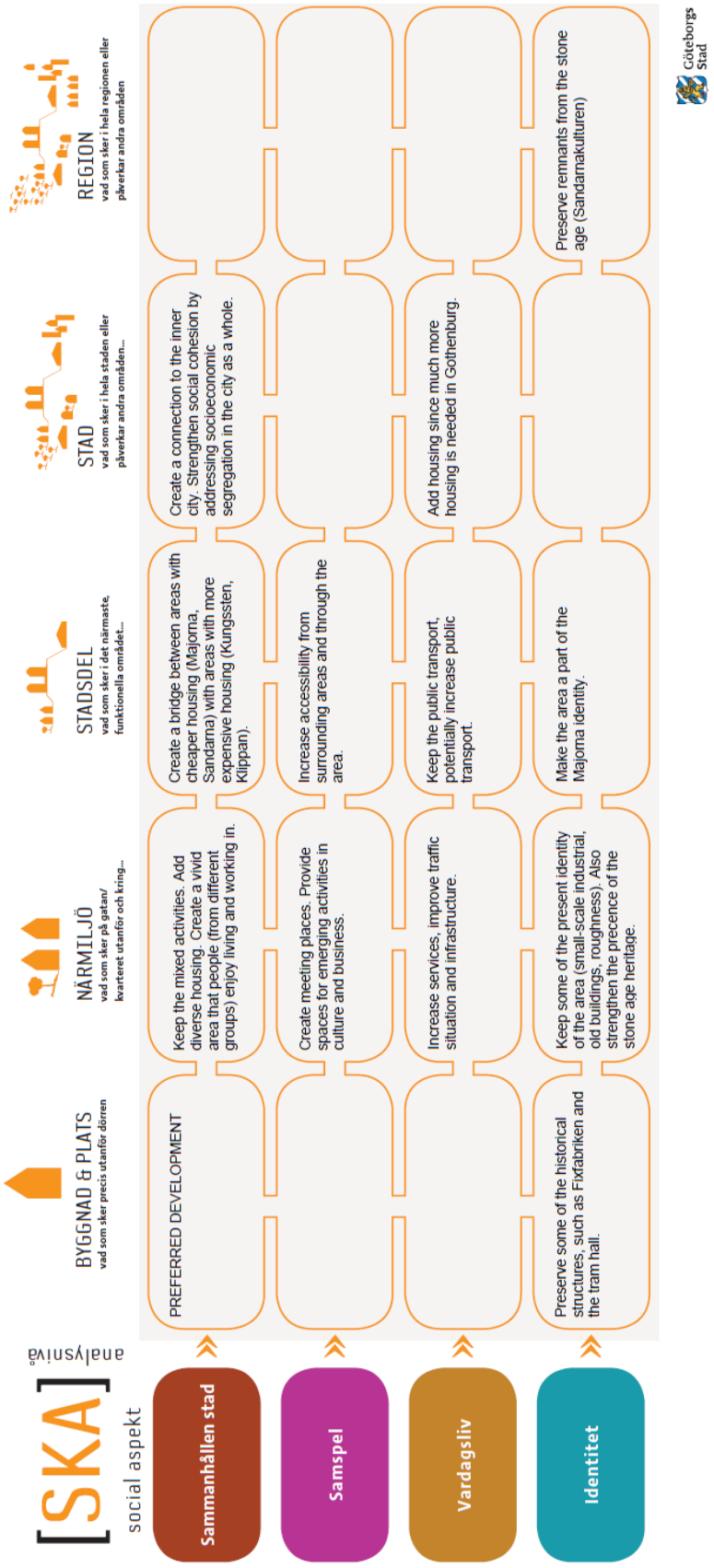


Figure B-3. Preferred changes.

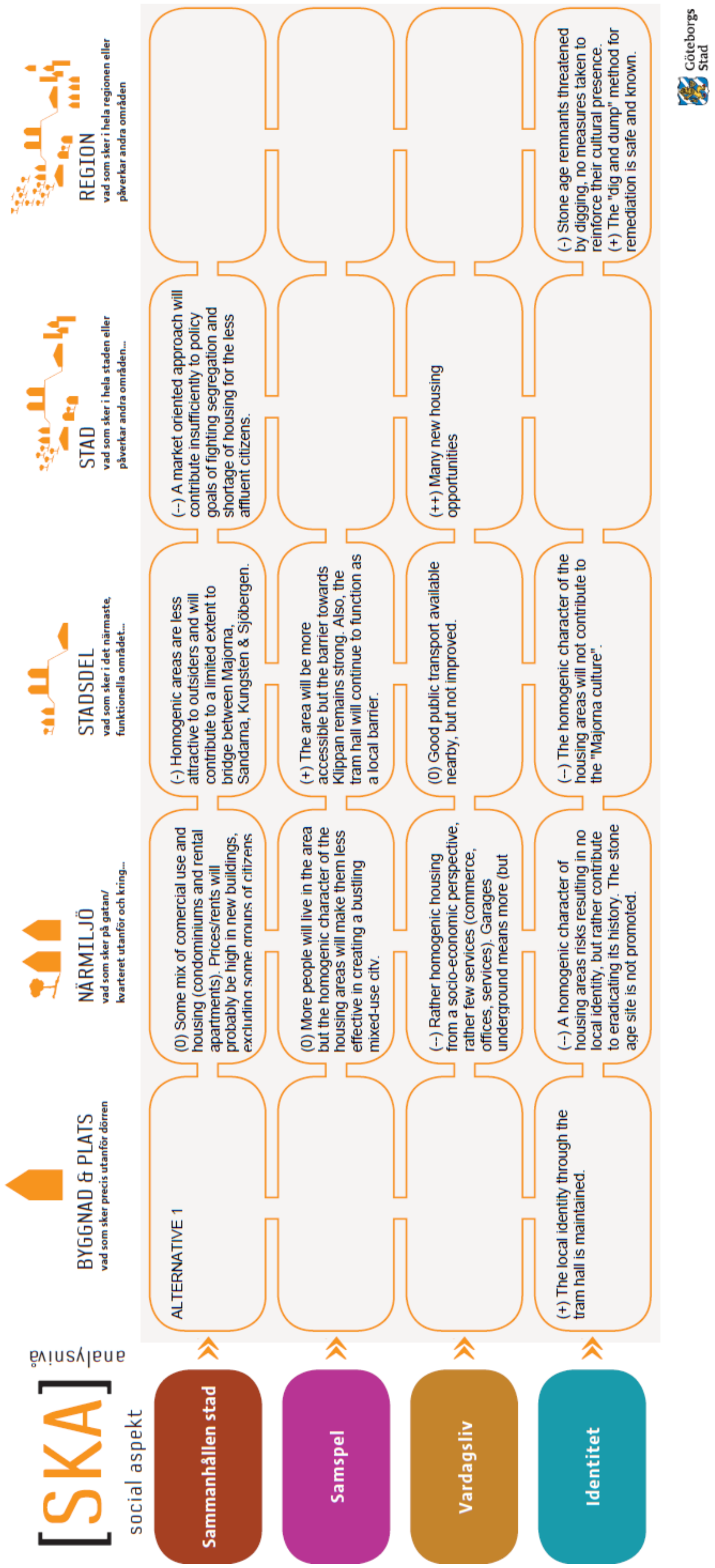


Figure B-4. Social impacts due to Alternative 1.

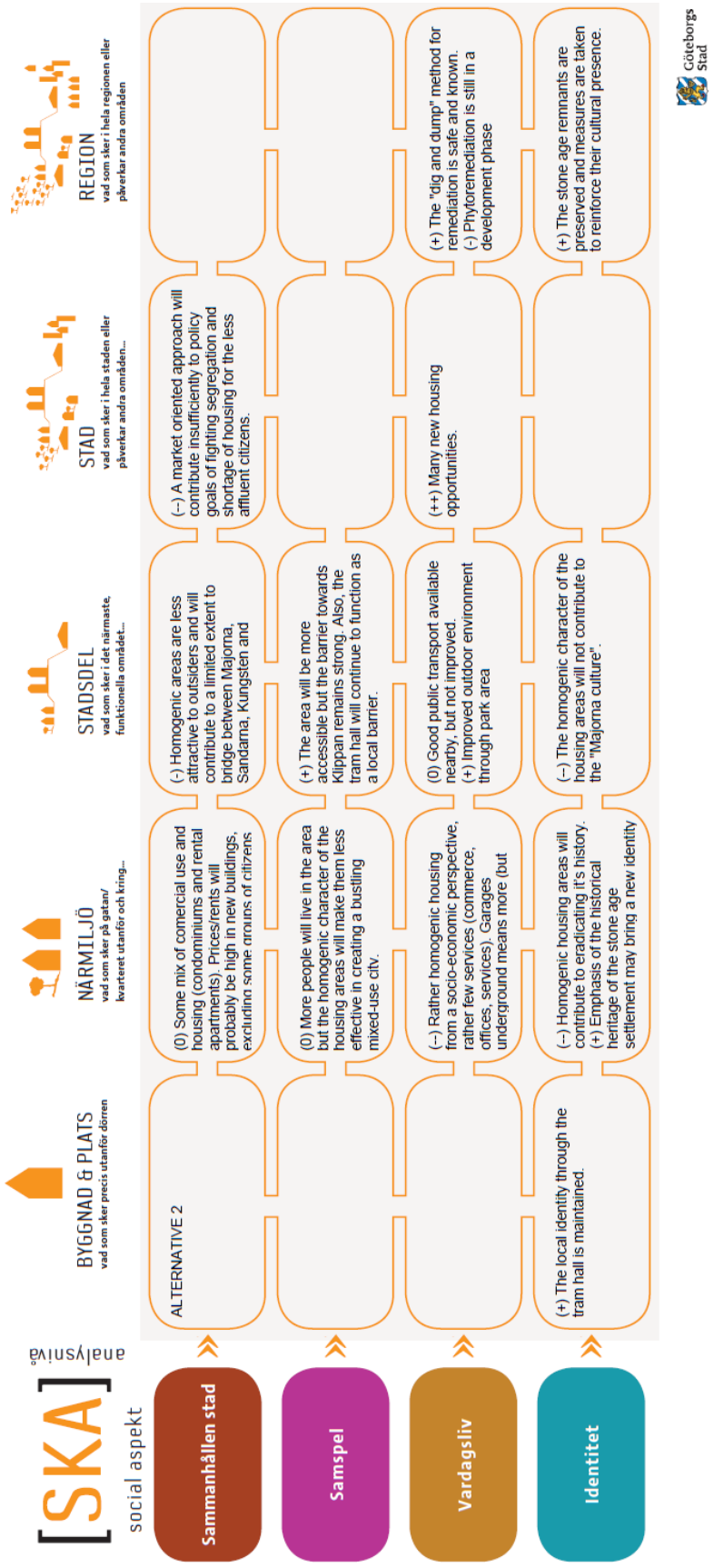


Figure B-5. Social impacts due to Alternative 2.

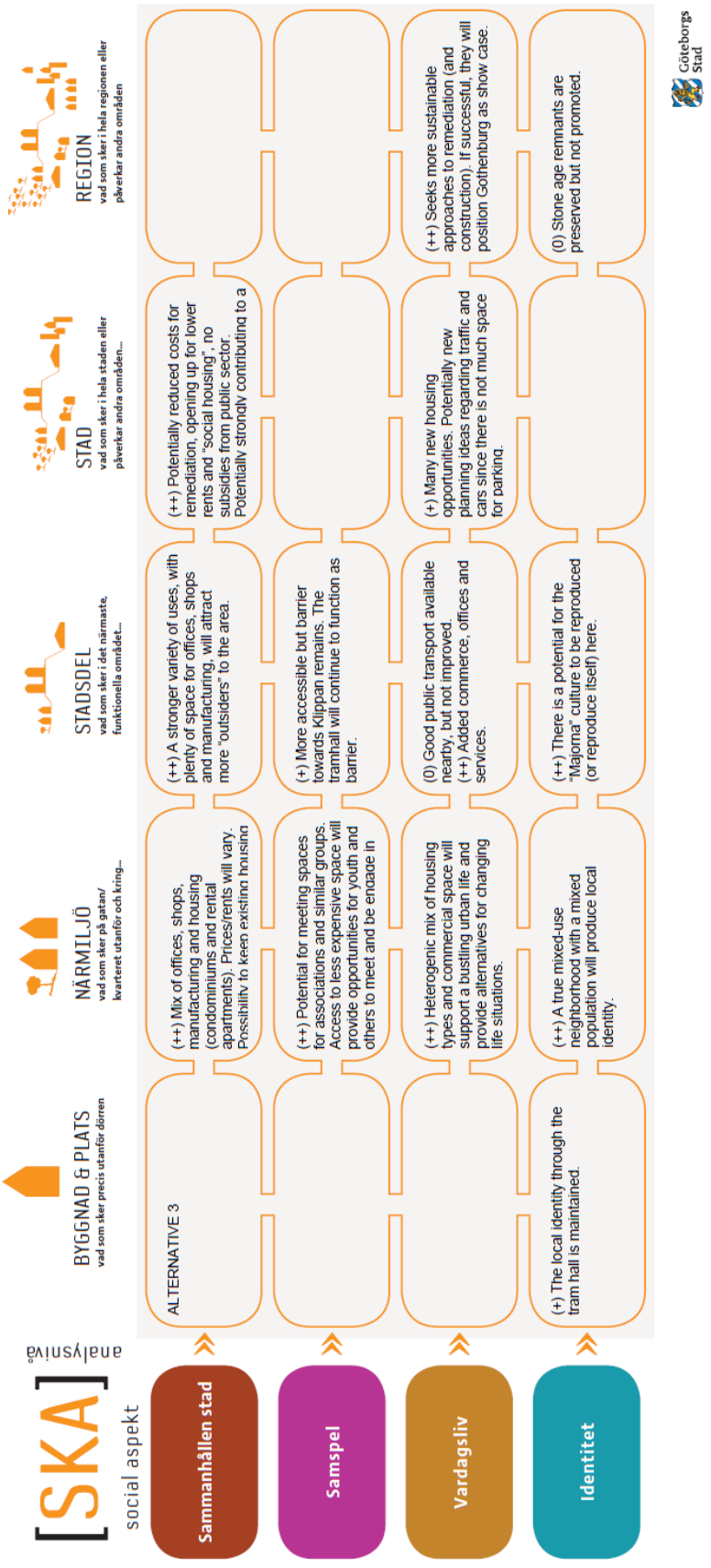


Figure B-6. Social impacts due to Alternative 3.

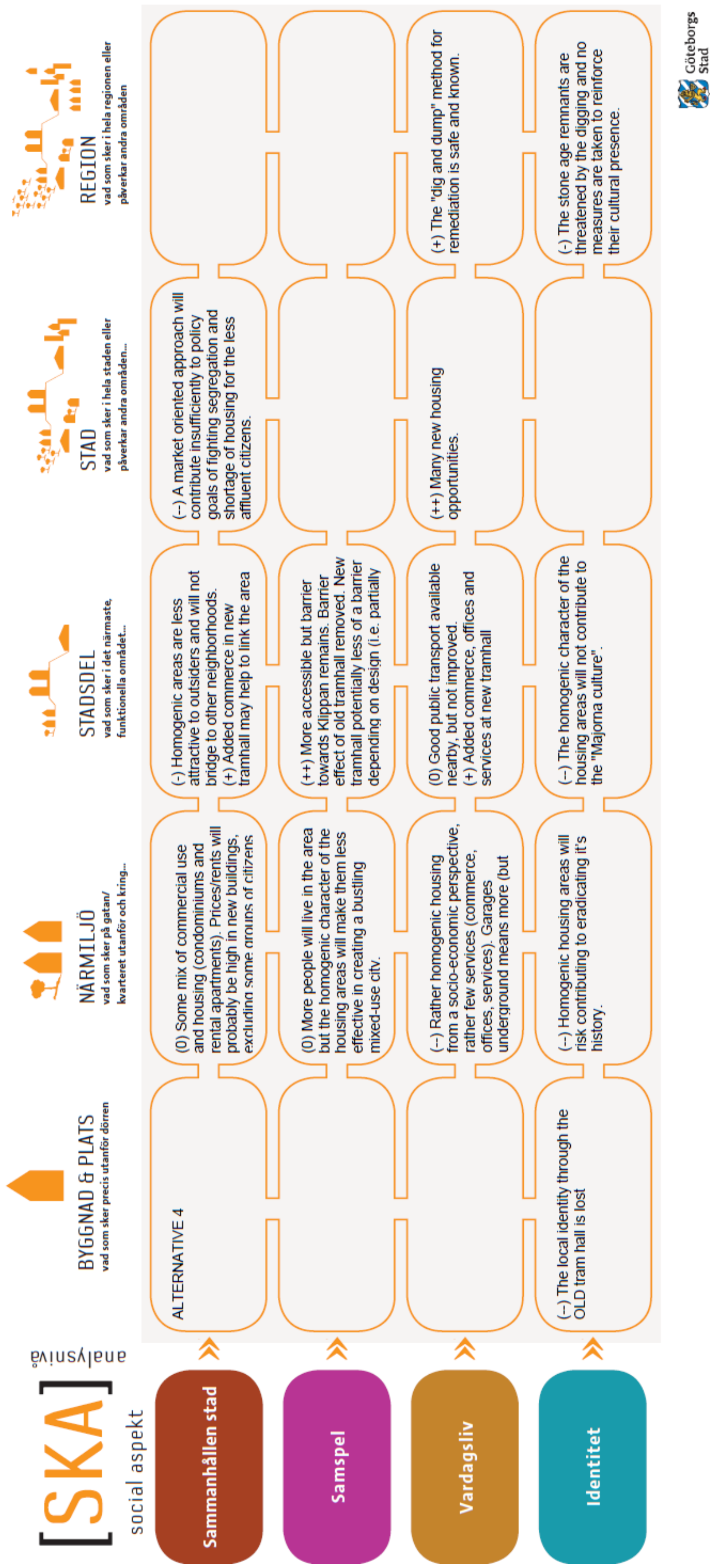


Figure B-7. Social impacts due to Alternative 4.

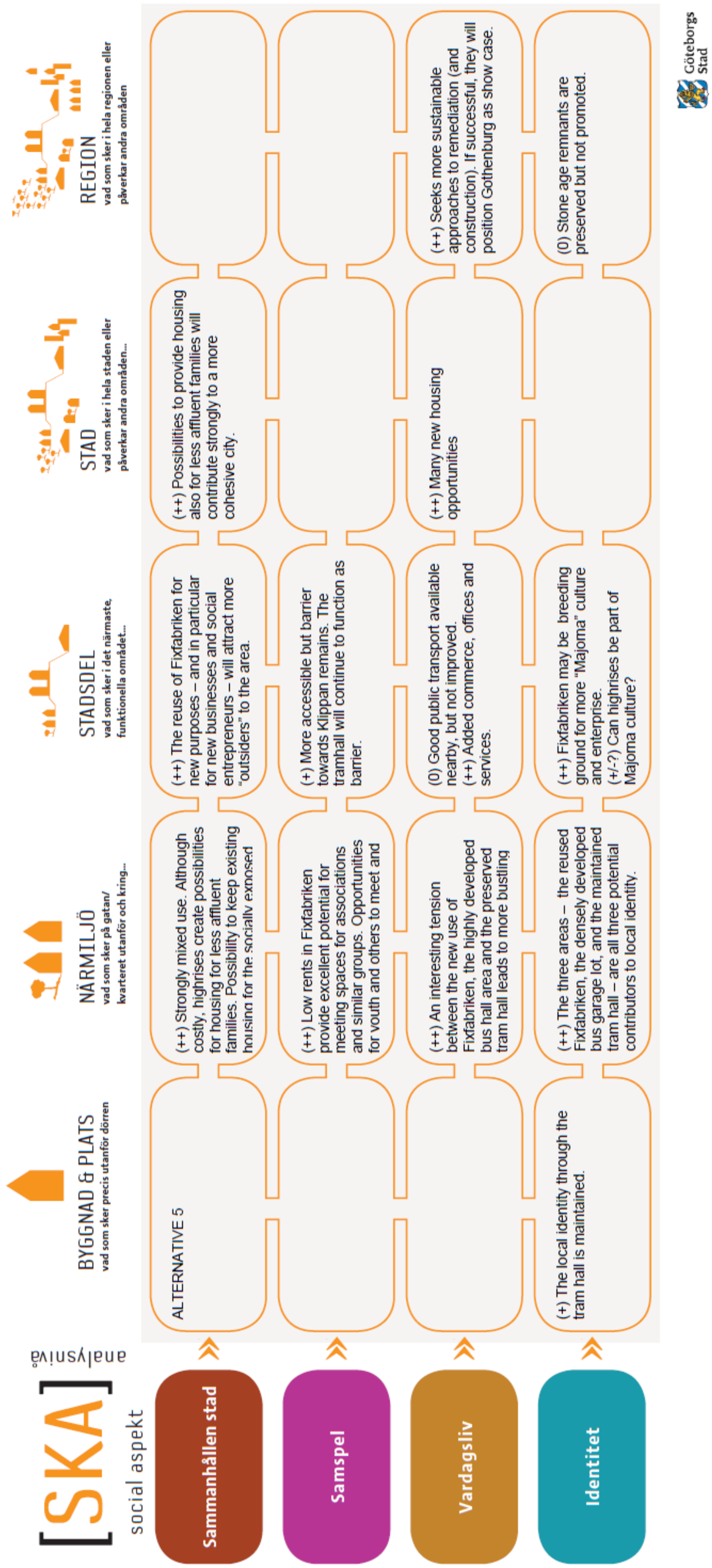


Figure B-8. Social impacts due to Alternative 5.

The impacts with regard to the different alternatives relative the reference alternative are summarized in Table B-1. For details, the matrices must be used.

Table B-1. Summary of impacts of the alternatives.

Alternative	**Total negative impacts**	**Total positive impacts**	**Total**	**Rank**
Alternative 1	-10	+5	-5	4
Alternative 2	-9	+8	-1	3
Alternative 3	0	+21	+21	2
Alternative 4	-12	+7	-5	5
Alternative 5	0	+22	+22	1